Quinsam Watershed Study: 1983

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ABSTRACT

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Hatchery coho and steelhead fingerlings have been transplanted to the Quinsam watershed, yearly, since 1978. In the winter of 1983 the opportunity arose to monitor the fish distribution and smolt production from this area. The study was extended to include the monitoring of stream flows and basic water quality parameters. The effort was intensified in the Middle Quinsam Lake area because this is the site of a proposed surface coal mine.

Trapping success indicated that the heaviest coho utilization occurred in Flume and Long Lakes. Steelhead were more abundant in the streams. Downstream migration began in late April. By the end of May it was estimated that at least 32,500 coho smolts had moved out of Middle Quinsam Lake area.

The lowest stream flow occurred in late spring and summer. The outlet of Long Lake was below 0.01 cubic meters per second for an extended period.

Suspended solids levels for the streams flowing into Middle Quinsam Lake remained low throughout the year (<3 mg/l) while the lower Quinsam River and the Iron River became quite silty (>20 mg/l) during storm events. pH values were generally above 7.0 and the dissolved oxygen levels were typically above 85% of saturation. Flume Lake outlet was exceptional in that the pH values were consistently below 7.0 and the dissolved oxygen level had decreased to 64% of saturation by August.

RÉSUMÉ

Blackmun, G.J., Lukyn, B.V., McLean, W.E., and Ewart, D. 1985. Quinsam watershed study: 1983. Can. MS Rep. Fish. Aquat. Sci. 1832 : ix X 65p.

Depuis 1978, des tacons de saumon coho et de truite arc-en-ciel anadrome sont mis en liberté chaque année dans le bassin versant de la rivière Quinsam. À l'hiver 1983, on a eu la possibilité de surveiller la répartition du poisson et la production de saumoneaux dans cette région. L'étude a aussi porté sur le débit fluvial et les paramètres fondamentaux de la qualité de l'eau, surtout dans la région du lac Middle Quinsam où l'exploitation d'une mine de charbon à ciel ouvert est proposée.

Selon les résultats de capture, le saumon coho fréquente plus souvent les lacs Flume et Long tandis que la truite arc-en-ciel anadrome est plus abondante dans les ruisseaux. La dévalaison a commencé à la fin d'avril. On a déterminé qu'au moins 32,500 saumoneaux de saumon coho avaient, à la fin de mai, quitté la région du lac Middle Quinsam.

Le plus faible débit a été enregistré à la fin du printemps et à l'été. À la sortie du lac Long, le débit a été inférieur à 0.01 m^3/sec pendant une longue période.

Les taux de solides en suspension dans les cours d'eau se déversant dans le lac Middle Quinsam sont restés faibles toute l'année (<3 mg/l) tandis que la partie inférieure de la rivière Quinsam et la rivière Iron sont devenues très vaseuses (>20 mg/l) au cours de tempêtes. En général, le pH étrait supérieur à 7.0 et les taux d'oxygène dissous étaient typiquement supérieurs à 85% de saturation, à l'exception de l'émissaire du lac Flume où le pH était toujours inférieur à 7.0 et le niveau d'oxygène dissous, en août, avait baissé à 64%.

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1. INTRODUCTION

1.1. Purpose and Scope of the Report

This report presents biophysical baseline data for the Quinsam watershed to assist in evaluation of the potential impacts of proposed mine development in the Upper Quinsam system. Water flow, water quality, fish distribution and migrant smolt enumeration data collected during the period March 1 to December 31, 1983 are included.

The primary objectives of the study were to: (1) determine the distribution of rearing salmonids in the Quinsam system; and (2) determine flows in the system. These objectives are of the utmost concern since fish utilization and flows of water adjacent to proposed development sites were unknown. Implementation of this work provided us with the opportunity to collect preliminary data on some factors of secondary importance, specifically: (1) water quality and (2) production of downstream migrating smolts.

The data presented are the first of their type available for the study area. We consider such information essential for decisions concerning multiple use of the resources of the Quinsam River watershed and, for this reason, are continuing data collection.

1.2. Description of the Watershed and Study Area

The Quinsam River watershed (Fig. 1) drains an area of 209 sq.km (108 sq.mi). The Quinsam River is the major tributary of the Campbell River and their confluence is 3.5 km above the Campbell River estuary. Major tributaries to the Quinsam River are Cold Creek, Iron River and Flintoff Creek. The Quinsam watershed is bounded north and west by a mountainous divide that isolates it from the Campbell watershed. Mean annual flow for the Quinsam River near its confluence with the Campbell River during the period 1956 to 1973 was 9.2 cubic meters per second (cms) (Bell and Thompson, 1977).

The study focuses on the Upper Quinsam watershed (Areas 1-5, Fig. 2). Middle Quinsam Lake, central to the study area is the proposed site for an open pit, thermal coal mine. The downstream limit to the main study area is the 12.2 m high waterfall located 1.2 km below the Outlet of Middle Quinsam Lake. These falls are the upstream barrier for migrating adult anadromous salmon and trout. Process effluent from coal washing, pit dewatering and other operations would discharge into the system at three points: (1) midpoint of the Long Lake south shore; (2) Outlet of Long Lake; and (3) the marsh area at the upstream end of Middle Quinsam Lake.

The study area consists of lakes, marshes and free-running streams. Lake and marsh areas were quantified using aerial photographs taken for forest inventory purposes (Kathy Hopkins, pers. comm.). Middle Quinsam, Long, No-Name and Flume

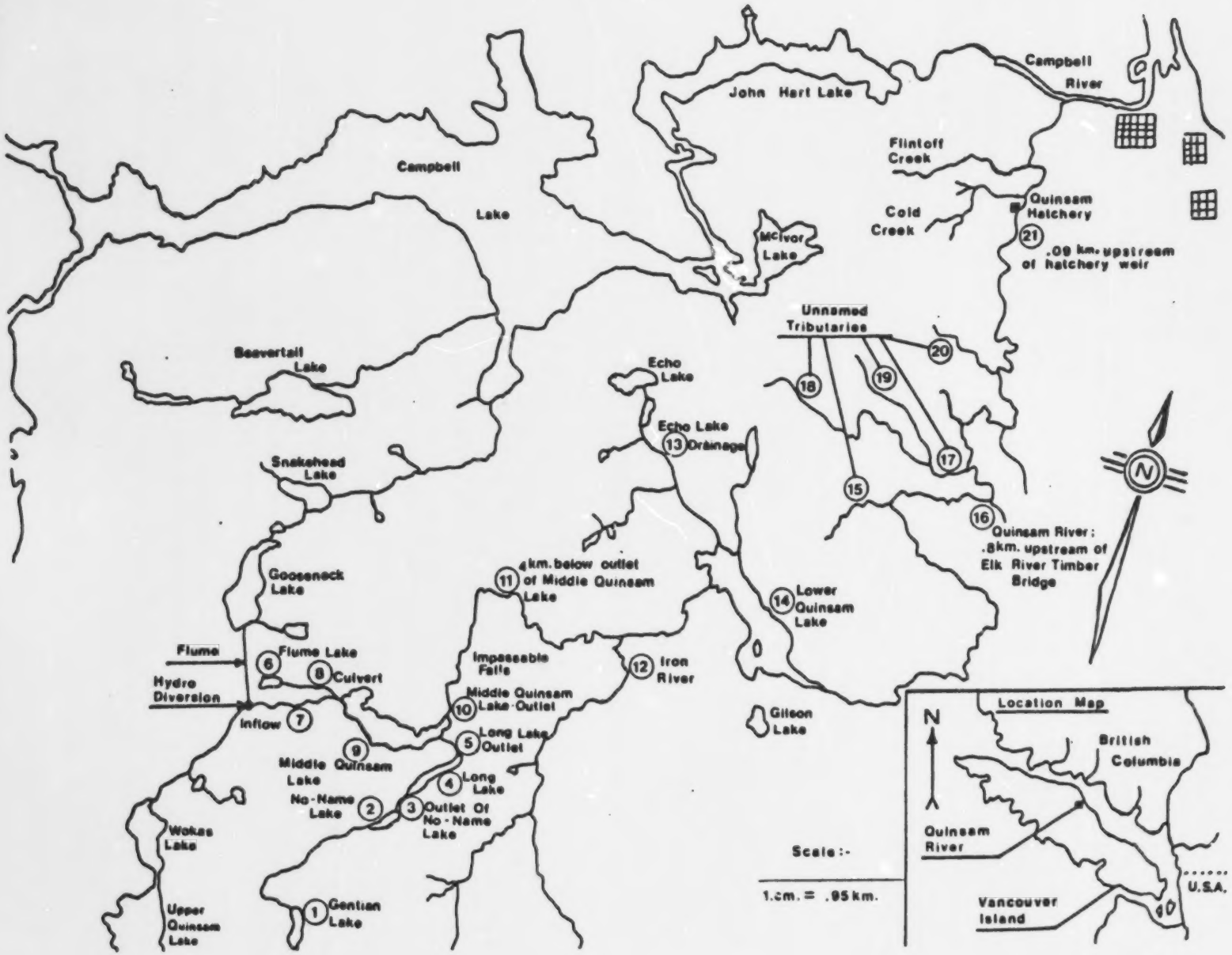

Fig. 1. Quinsam River Watershed sample site map.

lakes total approximately 106 ha. There are large marsh areas between Flume Lake and the head of Middle Quinsam Lake, and at the head of No-Name Lake. Total marsh area is approximately 82 ha. Total free-running stream length is 4.4 km including: (1) British Columbia Hydro and Power Authority (B.C.H.P.A.) diversion dam to Middle Quinsam Lake, 1.9 km; (2) Outlet of Middle Quinsam Lake to the impassable falls, 1.2 km; (3) Long Lake to Middle Quinsam Lake, 0.8 km; and (4) No-Name Lake to Long Lake, 0.5 km (Lawseth, 1977).

1.3. Flow Regulation

Flows in the Quinsam system have been regulated by B.C.H.P.A. since 1956. There is a storage dam on Upper Quinsam Lake and a diversion dam above Middle Quinsam Lake which diverts Quinsam water via Gooseneck Lake into the Campbell system. This water is used for hydro-electric power generation. There were no established minimum flow requirements for the Quinsam system prior to 1963. The B.C.H.P.A. water license, revised in 1963, established flow requirements for the Quinsam River above Middle Quinsam Lake and immediately below Lower Quinsam Lake. Even with flow regulation flooding still occurs in the lower river and possibly in other areas of the watershed.

1.4. The Salmonid Resource

The lower Quinsam River is utilized by all five species of Pacific salmon (coho, chinook, chum, sockeye and pink) and by two species of sea-run trout (steelhead and cutthroat). These fish are described as anadromous since they typically reproduce in fresh water, spend variable lengths of time rearing in lakes or streams and then migrate as smolts to the ocean where they remain for one to five years. They return to their home stream to spawn when sexually mature.

Anadromous salmonids cannot pass the waterfall below Middle Quinsam Lake; thus the upstream reaches were historically devoid of sea-run species. Non-migratory trout were the most important fish species in the Upper Quinsam.

The Quinsam Salmon Hatchery, located on the lower Quinsam 3 km above the Campbell River (Fig. 1), began operation in 1974. It was built to enhance anadromous salmon and trout of the Quinsam and neighbouring streams. Hatchery production prior to 1978 was limited to release of young fish fully reared and ready to enter saltwater. In 1978, a new program was started to further increase returns. This involved planting of pre-migrant coho salmon and steelhead trout fingerlings in the Upper Quinsam watershed in September. These fish rear in areas which were underutilized due to the limits on distribution of migrating adults. They generally remain in fresh water until the spring after they are planted at which time they smolt and migrate to the sea.

About 1,600,000 hatchery incubated coho and steelhead have been planted throughout the Upper Quinsam since 1978 and the

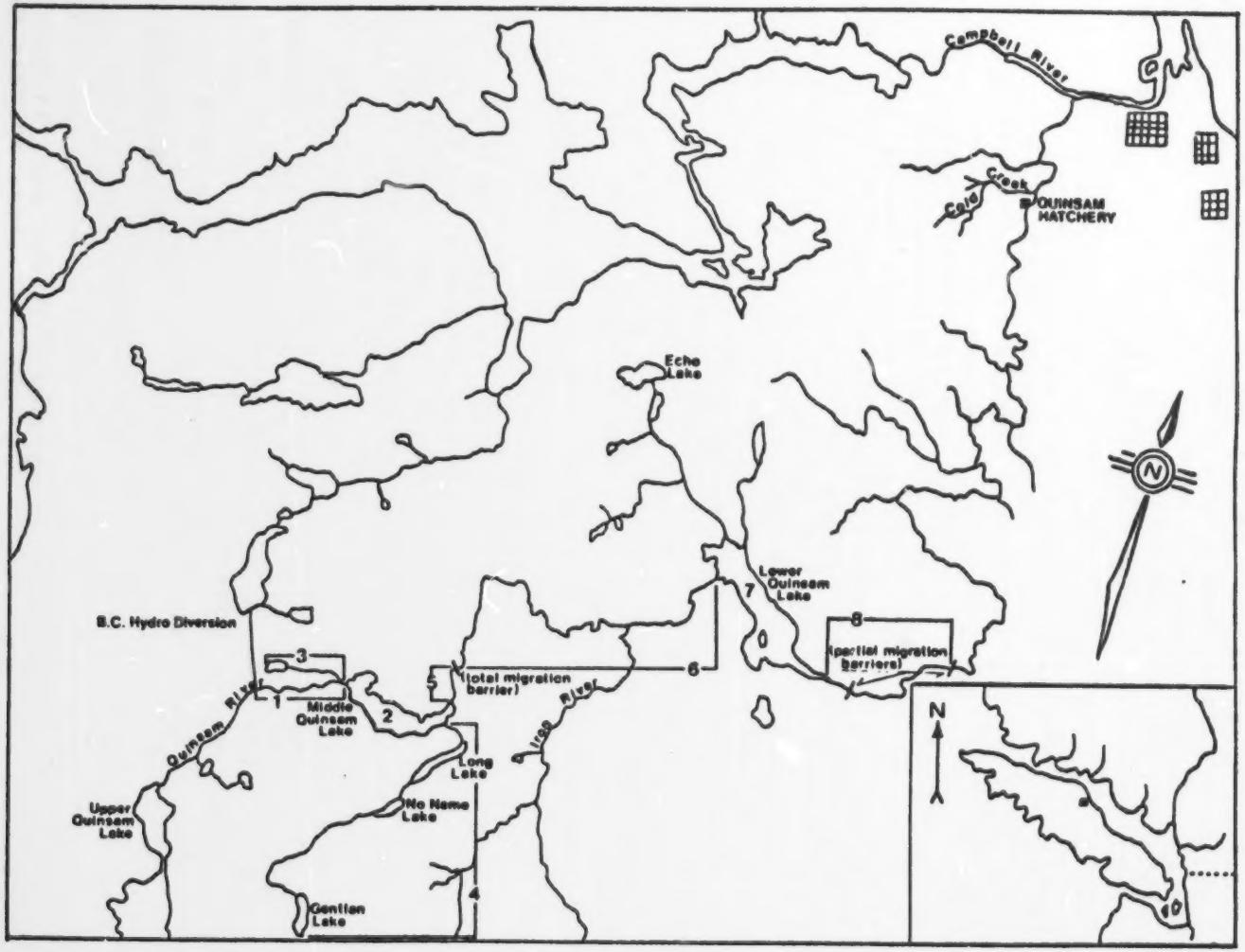

Fig. 2. Coho colonization areas of the Quinsam River - sites are indicated by areas numbered 1 to 8.

number of planting areas have increased from three in 1978 to eight in 1981 and 1982 (Tables 1, 2; Fig. 2). Coho and steelhead that rear in Areas 1-4 (Fig. 2) must migrate through Middle Quinsam Lake to reach the sea. It is known that these planted fish survive at high rates to smolt and adult stages. For instance, 27% of the smolts resulting from the first transplant (1977 Brood Year) survived to the adult stage (Ted Perry, pers. comm.). Prior to the current study, however, it was not known which areas of the Upper Quinsam system were used by the fish after planting. The data presented indicate that lakes and streams throughout the study area are heavily utilized.

Salmonid production in the Quinsam River system is, in summary, dependent on three components: (1) natural spawning and rearing; (2) hatchery release of smolts ready to enter the sea; and (3) hatchery release of fingerlings which must rear in freshwater before entering the sea. Fish produced by each of these strategies contribute heavily to our fisheries, both recreational and commercial and to the escapement essential for their survival. The economic worth of Quinsam River salmonids has been evaluated and is substantial (Quinsam Coal Task Force Report, 1982; Read and Poulin, 1982).

2. MATERIALS AND METHODS

2.1. Flow Data

Stream flow measurements were carried out at six sites (Table 3). In order to develop water level vs. discharge relationships, staff gauges were installed at each site and a series of stream flow measurements were made. Two of the gauges were installed by Norecol Environmental Consultants Ltd.[1] on behalf of the Quinsam Coal Company (sites 3 and 10). The remaining gauges were installed by Quinsam Hatchery personnel.

Table 3. Flow gauging stations.

Site Number	Site Name	Abbreviation
3	Outlet of No-Name Lake	No-Name
5	Outlet of Long Lake	Long Lk.
10	Outlet of Middle Quinsam Lake	Out MQL
21	Quinsam River at Hatchery	Q. Riv
12	Iron River	Iron
7	Inlet to Middle Quinsam Lake	In MQL

1 Norecol Environmental Consultants Ltd., Suite 100, 1281 West Georgia St. Vancouver, B.C. V6E 3J7

Flow measurements at the six sites were performed using Gurley current meters. Since the water velocities encountered over the study period varied widely, two differently sized meters were required. A Gurley meter (model 622-AA) was used for water velocities between 0.06 m/s (meters /second) and 7.0 m/s while a Pygmy meter (model 625) was used for lower velocities (0.015 m/s to 0.914 m/s).

The Pygmy meter, with its sensitivity for measuring lower velocities was required at sites 3 and 5 only. The flows at these sites dropped dramatically during the summer months. Velocites at these sites fell beneath the minimum threshold (<.015 m/s) of the Pygmy meter by the middle of June. Sandbags had to be laid down in order to reduce the cross sectional area of the stream, thus increasing the velocity to a point measurable by the Pygmy meter. Stream flow measurements were conducted in accordance with the procedure described by Arseneault, 1976. All flow measurements have been expressed in units of cubic meters per second (cms).

The high flows that occurred during a storm event in November 1983 were estimated by measuring the dilution of the fluorescent dye "Rhodamine B". These measurements were performed by Norecol Environmental Consultants Ltd. (Brian Guy pers. comm.).

2.2. Distribution and Migration of Colonized Salmonids in the Quinsam River System

2.2.1 Minnow trapping

A trapping program was undertaken between March 8 and April 22, 1983 to determine species distribution prior to the downstream smolt migration. Standard Gee minnow traps (K. Conlin and B.D. Tutty, 1978), were utilized to obtain these data. Ten Gee traps (baited with frozen salmon roe) were set out at 17 sample sites. The Gee traps were fished over a 24 hour period. Fish from these traps were anesthetized with 2-phenoxyethanol. They were then identified, counted, examined for marks, measured for fork length and finally liberated.

2.2.2 Downstream trap at the Outlet of Long Lake

In order to evaluate the downstream migration of colonized coho rearing in the Long Lake, No-Name Lake system, a trap was installed 22 meters downstream of the Outlet of Long Lake (site 5). The trap, which was operated from April 18 to June 1, 1983, consisted of a 1 meter square opening hung with .6 cm mesh netting, and tapered downstream 2.5 meters to connect with a plastic flex hose 10 cm in diameter. The flex hose ran downstream 3.48 meters to a live holding box (.70 m deep x .74 m wide x .85 m long) (Fig. 3).

Coho smolts captured by this trap were marked in two ways: (1) left ventral fin clips and (2) the attachment of colour coded aluminum staples. These fish were held for a minimum of 10 hours to check for delayed marking mortality. After this time

they were released above the trap for recapture and evaluation of trap efficiency.

2.2.3 Downstream trap at the Outlet of MQL

A 12 meter wide removable weir was installed at the Outlet of Middle Quinsam Lake (site 10) to enumerate colonization coho and steelhead migrating out of the upper watershed. Site 10 is approximately 27.5 km upstream from the Quinsam Hatchery. This trap was operated from April 15 to June 1, 1983.

A .85 meter long flume was attached to the brim of one section of the weir (Fig. 4). Fish entering this flume were directed to a live holding box (.85 m deep x .74 m wide x 1.28 m long) located 1.9 meters downstream from where the flume joins the weir.

The mark recapture method was also used in an attempt to measure trap efficiency at the Middle Quinsam Lake site. On April 20, May 2, 3 and 9, marked coho were released above the weir. Recapture rates from these attempts were too low for trap evaluation purposes and so this method was abandoned.

Trap efficiency was finally determined by installing a beach seine (0.6 cm mesh) along the entire length of the weir. Thus, the combined numbers of fish captured in the seine and the trap represented 100% of the daily migration. The number of fish captured by the trap alone was then compared with this total value to obtain a measurement of the trap efficiency. Three independent measurements of the daily trap efficiency were obtained over the study period (May 18, 19 and 20).

Population estimates of steelhead were not obtained at this site due to trap avoidance, variance in migration timing and extremely low capture numbers.

2.3. Water Quality and Temperature Data

Sampling began in late March 1983 and will be ongoing for at least the next two years. Once a week sampling is conducted at seven sites, generally between the hours of 0900 and 1500. All sites are sampled for dissolved oxygen (DO), pH, and temperature - four of these sites are also being sampled for non-filterable residue (NFR). Also, metal and nutrient data were obtained from site 21 (Quinsam River at Hatchery).

2.3.1. Temperature and pH

From March to mid-April temperatures were measured weekly at each sample site using a hand held thermometer (0.1° C graduations). Between April 1 and August 15, 1983 three devices were used to obtain records of daily temperatures. Ryan recorders (self-contained 45 day submersible Peabody-Ryan model No. F-45) were used at sites 7, 8, 10 and 5 from March 23 to July 21, 1983. Taylor thermographs (7 day -20° to 30° C) were installed in late June at the outlets of Middle Quinsam Lake and Long Lake. In addition to these continuous temperature records, frequent spot

checks at all sites were made using hand held thermometers. Daily temperatures, where possible, are the means of all three methods.

Samples for pH analysis were collected in 500 ml plastic bottles, stored in a cooler and transported back to the Quinsam Hatchery. pH was measured at the hatchery using a Fisher Accumet Model 420 digital pH/Ion meter. From mid-April on, weekly temperature and pH measurements were taken in-situ using a Fisher Model 119 portable pH/Temperature meter.

2.3.2. Dissolved oxygen and % saturation level

Dissolved oxygen was measured at each sample site using a Leeds and Northrup model 7932 portable dissolved oxygen meter. When the portable meter was not available for use, water samples were collected in duplicate and fixed at the sample sites. They were then transported back to Quinsam Hatchery where they were measured for dissolved oxygen using the azide modification of the Winkler method (Standard Methods, 1975). Barometric pressures were also measured at each sample site. Oxygen concentrations were then compared with the equilibrium concentrations (100% saturation) reported by Hitchman (1978) and the % saturation levels were calculated.

2.3.3. Non-filterable residue (suspended solids)

Samples for non-filterable residue analysis were collected from four sites using 4 liter washed and sealed plastic buckets. These samples were transported within one hour to Quinsam Hatchery for analysis. Samples were analyzed according to Standard Methods, 1975. Nine cm. diameter Reeve Angel 934AH glass fiber filters were rinsed with 200 ml distilled water and dried for one hour at 103° C. The filters were then dessicated for thirty minutes (to room temperature), before being weighed using a Mettler H54 mechanical analytical balance. Two liters of sample were then suctioned through the prepared filters - the filters were then redried, dessicated and reweighed to determine the non-filterable residue by weight (mg/l). To check the sensitivity of this method, two liters of distilled water was also suctioned through a filter and used as a control. In addition, duplicate samples were routinely taken from site 10. Comparison of duplicates was used to give an indication of the reproducibility of the method.

2.3.4. Metals and nutrients

Water samples were also taken once per month at the Hatchery site (Quinsam River at Hatchery, site 21). These samples were sent to the Department of Fisheries and Oceans Water Chemistry Lab in West Vancouver for nutrient and metal analysis. Metal samples were taken in duplicate and filtered through a 0.45 micron millipore filter at the hatchery before shipment to the

Laboratory. This allowed determination of both "dissolved" and "extractable" metal concentrations.

3. RESULTS AND DISCUSSION

3.1. Minnow Trapping

The Gee minnow trapping program was carried out between March 8 and April 22, 1983. The information obtained was used to indicate the species distribution. Also, captured coho, steelhead and cutthroat were examined for marks and measured for length. These data are summarized in Tables 10, 11 and 13.

Coho transported to the upper Quinsam in September 1982 were not marked. However, 34% of fish transplanted in September of 1981 were adipose clipped. Therefore presence of a clipped coho in the Gee traps would indicate a 2 year old fish.

Steelhead fingerlings colonized to the upper watershed in September of 1982 were marked in two ways. Left maxillary clips denoted fish released to rivers (Iron or Quinsam) while right maxillary clips denoted fish released to lakes. Mark recovery data is summarized in Table 12. Interpretaton of these data will not be attempted in this report. The steelhead marking operation is an ongoing program of the B.C. Fish and Wildlife Branch (Bob Hooten pers. comm.). The reader is referred to this agency for a more complete analysis of the mark recovery information.

The trapping operation yielded a total of 498 coho, 208 steelhead, 57 cutthroat and 75 other fish (dolly varden, sculpin and stickleback). Catch data is presented by area in Table 14 while species distribution is shown in Figure 17.

Six sites above the falls and nine sites below the falls were trapped with equal intensity. The area above the impassable falls accounted for 51% of the captured coho. Long Lake and Flume Lake (sites 4 and 6, Fig. 17) were by far the most productive sites for coho. These lakes accounted for 79% of the coho captured above the falls and 40% of the total catch. It is interesting to note that of the 102 coho trapped in Long Lake (using 10 traps) at least 30 coho were captured in one trap located on the lake bottom (42 ft. deep).

Steelhead were trapped almost equally at four river sites (site 10, 11, 12 and 16 in Fig. 17). These sites accounted for 96% of the catch. No steelhead were trapped in Flume or Long Lake.

3.2. Downstream Smolt Migration

3.2.1 Outlet of Long Lake

Numbers of cutthroat and coho captured at the Outlet of Long Lake trap are shown in Tables 15 and 16. In total, 51 cutthroat and 3257 coho were captured over the 45 day trapping period.

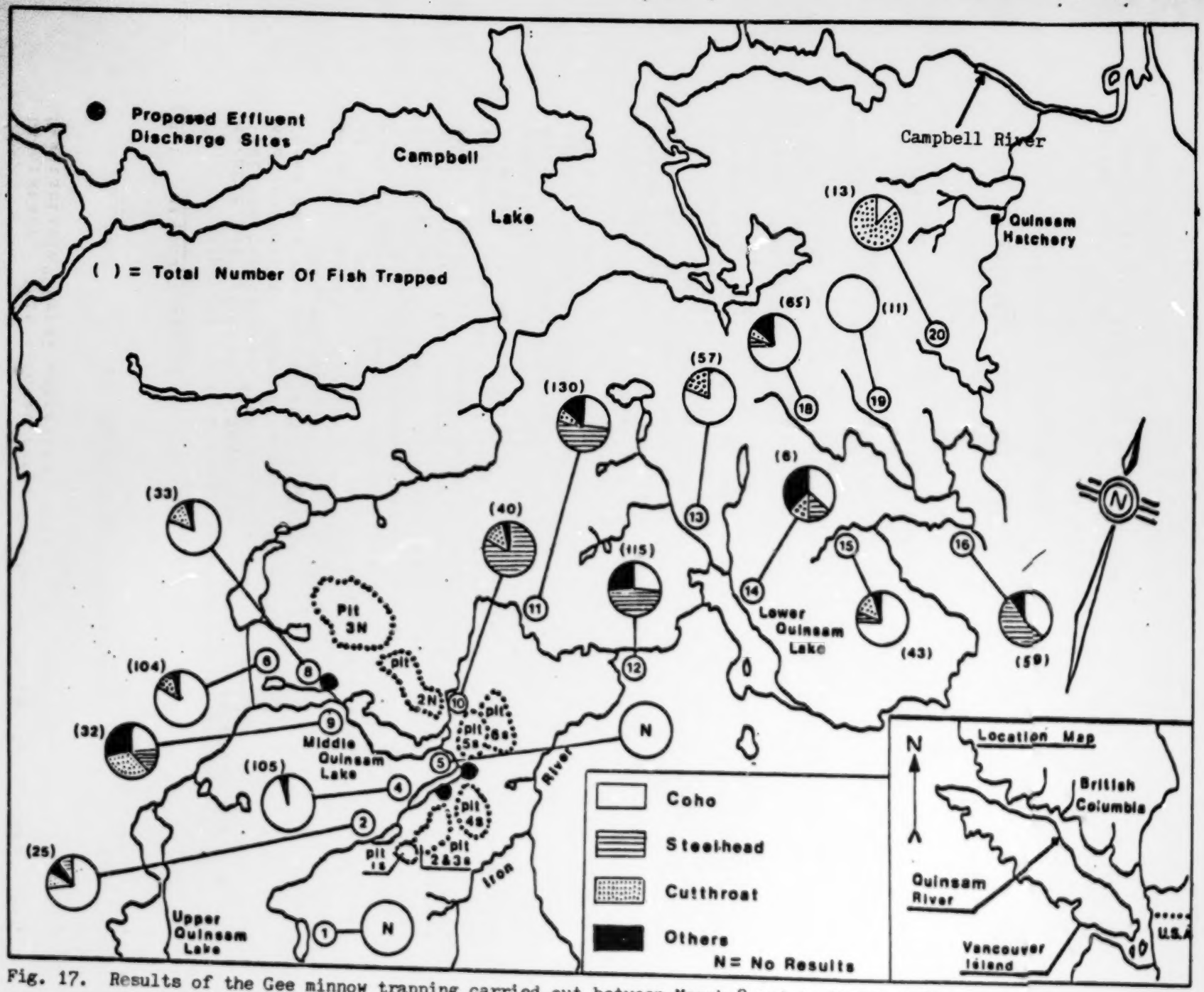

Fig. 17. Results of the Gee minnow trapping carried out between March 8 and April 22, 1983.

Trap efficiency was calculated by releasing a known number of marked fish upstream of the trapping gear and noting the percentage of marks subsequently captured in the trap. Coho, marked by means of a left ventral fin clip, were released on April 20 (72 fish) and on May 4 (97 fish). Of the 169 marked fish released, 48 marks were captured in the trap between April 27 and May 12. These results gave a trap efficiency of 28.4% (catch coefficient = 3.52). It should be noted that the period between April 4 and May 12 was characterized by higher water flows (range 0.06 cms to 0.30 cms, see Table 15 or Fig. 12).

Lower water flows (range 0.01 cms to 0.05 cms) and reduced trap efficiencies existed between May 13 and June 1. On May 13, 127 staple marked coho were released upstream of the trap and on May 17 another 104 coho, marked with a different colour staple were released. Between May 14 and May 19, 26 of these staple marked fish were captured in the trap. These results indicated a trap efficiency of 11.3% (catch coefficient = 8.88). Mark and recapture information required to calculate trap efficiencies over the high and low flow periods is summarized in Table 22.

An estimate of the daily migration was obtained by multiplying the appropriate catch coefficients by the daily catch. These estimates are shown in Table 16. These calculations show that 16,400 coho smolts migrated out of Long Lake between April 18 and June 1. Seventy-five percent of these smolts migrated over a 12 day period extending from May 8 to May 19.

The smolt output has been inferred from a sample of the downstream migration and so is necessarily subject to statistical uncertainty. This uncertainty is reflected in the magnitude of the 95% confidence interval. The lower 95% confidence limit is proposed as a conservative estimate of smolt output. In fact, there would be a high probability that the number of downstream migrants would exceed this conservative estimate.

The downstream estimates and 95% confidence limits were obtained using the unadjusted Petersen estimator and the normal approximation to the hypergeometric distribution as described in Chapman (1948). This analysis yielded a lower 95% confidence limit of approximately 12,700 fish. This method gives similar results to the methods used by Lister et. al. (1979) in the enumeration of the coho smolt output of the Little Qualicum River.

It is not possible to calculate the fry to smolt survival for fry transplanted to the Long Lake system (Area 4 in Fig. 1). Although only 18,000 fry were transplanted to this system in September of 1982, this area is accessible to fry transplanted to the Middle Quinsam Lake area. Although there is no direct evidence that coho fry move upstream to this system, it is known that some steelhead fry originally transplanted to the Quinsam River moved through Long Lake to No-Name Lake. This is indicated by the fact that two marked steelhead were captured in Gee Minnow traps at No-Name Lake in March 1983 (Table 14).

A quantitative estimate of fry to smolt survival would be further complicated by the broad confidence interval associated with the measurement of smolt output. Further monitoring is required to fully assess the potential of the Long Lake system. It is recommended that fry movements be monitored immediately

following the September transplant operation. This would show whether significant numbers of fry move into this system from Middle Quinsam Lake. It is also recommended that the uncertainty in the estimate of the smolt output be reduced. This could be achieved by involving larger numbers of marked fish in the measurement of trap efficiencies and by testing the trap efficiency more frequently.

3.2.2. Outlet of Middle Quinsam Lake

A total of 1,816 coho, 39 cutthroat and 27 steelhead were captured by the trap located at the Outlet of Middle Quinsam Lake. Because of the small numbers of steelhead and cutthroat caught, no inferences were made about the total number of migrants. However, the coho output of Middle Quinsam Lake was estimated from three independent measurements of trap efficiency. On May 18, 19 and 20, 100% of the downstream migration was captured and compared with the numbers of fish caught in the trap (Table 21).

These measurements showed that on average, 3.91% of the coho passing out of the lake were captured in the trap. This figure was used to calculate the number of downst eam migrants (Table 18). In total 46,453 coho were estimated to have passed the trap by June 1, 1983.

The estimated catch coefficients used to calculate the number of coho migrants varied between 24.5 and 30.0. Although the variability in the catch coefficients was fairly low, the fact that only three tests were performed introduced a large uncertainty into the migration estimate. On the other hand, it should be pointed out that the measurements of trap efficiency were made at a time when river flows were representative of those experienced during the peak of the downstream migration (see Table 6). In fact, between April 26 and May 19 - a period over which 94% of the fish moved downstream - the average river flow was 0.798 cms. This was comparable to the flow of 0.779 cms measured at the time the trap efficiency tests were made.

Because the trap efficiency measurements involved 100% trapping, they were not subject to statistical uncertainty - the tests performed on May 18, 19 and 20 were absolute measurements of trap efficiencies on those particular days. Because of this, the uncertainty associated with the estimate of the numbers of downstream migrants depended on the day to day variability in trap efficiencies and on the number of days the trap efficiency was measured.

With these considerations in mind, confidence limits have been calculated. The lower confidence limit of 32,500 coho has been tentatively proposed as an estimate of the numbers of coho passing the trap at Middle Quinsam Lake during the spring of 1983. It is realized that these estimates have a large uncertainty - proposals are made later in this report to repeat the downstream enumeration program in 1984.

In September of 1982, 63,000 coho fingerlings were transplanted to the area above the impassable falls (Areas 1-5 shown in Fig. 2). If the more conservative estimate of smolt

output is used (32,500), it means that at least 51% of these fish survived to the smolt stage.

The area below the falls (Area 6, 7 and 8 as shown in Fig. 2) received the remainder of the 248,000 transplanted fish. Unfortunately, the fish transplanted in 1982 were not marked. Therefore the smolt enumeration program operated at the Hatchery counting fence over the spring of 1983 could not differentiate between wild and transplanted fish. Hence the total smolt production from the 248,000 colonized fingerlings could not be assessed.

Measurements taken over the last 4 years, indicate that survival of colonized fingerlings has varied between 14% and 24% (Table 1). Although a definitive statement cannot be made from such a comparison - this information suggests that the survival of colonized fish above the falls is at least twice the survival in the downstream areas. In fact, this area accounted for at least 30% of the 109,000 wild and colonized coho smolts that migrated past the fence at the Quinsam Hatchery in 1983.

The obvious importance of this rearing area merits repeat of the monitoring program. In September 1983, 242,525 coho fingerlings were transplanted to the areas upstream of the hatchery; 42% of these fish were marked. Fence operations at the hatchery over the spring of 1984 should allow more precise enumeration of both wild and colonized smolts.

3.3. Water Quality

Water monitoring (pH, temperature and oxygen) was performed routinely between March 24 and December 31, 1983. Non-filterable residue (NFR) testing began on June 3 at four sites. These data are presented by site in Tables 24 to 30. Sample site locations are shown in Figure 1.

As expected, oxygen concentration tended to decrease as temperature increased. However, the oxygen level as a percent of saturation remained constant at some sites but decreased substantially at others.

For example, at the Inlet to Middle Quinsam Lake (site 7, Table 30) oxygen levels stayed above 90% of saturation over most of the study period. At Flume Lake outlet (site 8, Table 28) oxygen levels dropped from 91% on March 24 to 64% of saturation on August 12, 1983. This value represented a dissolved oxygen concentration of 5.7 mg/l. This was the lowest oxygen concentration measured over the study period.

The Flume Lake outlet also had the lowest pH values. Values ranged between 6.45 and 7.42. The highest pH values were measured at the Inlet to Middle Quinsam Lake (range 6.77 to 7.89).

Attempts were made to quantify the very low levels of suspended material in the water (non-filterable residue). Because large samples volumes were required; large diameter, medium fast glass filter disks were used for the analysis. Replicate testing at the Outlet to Middle Quinsam Lake was carried out in order to assess the measurement and sampling error. Also, the method was further checked by running a distilled water "control" with each

set of replicates. Results for 10 pairs of replicate samples are shown in Table 38.

The distilled water controls showed some variability: generally values fluctuated around "0" mg/l. This indicated that there was no gross systematic error associated with the analysis. The replicates also showed that a single measurement of low level suspended solids (NFR) has an uncertainty associated with it of $\pm$ 0.4 mg/l.

Most of the samples tested were very low in suspended solids. The sites located in the upper watershed (#3 - Outlet of No-Name Lake, #5 - Outlet of Long Lake, #7 - Inlet to Middle Quinsam Lake, #9 - culvert Outflow of Flume Lake, #10 - Outlet of Middle Quinsam Lake) had NFR values below 1 mg/l for much of the time. Even during a winter storm event of mid November solids levels in the upper watershed remained below 3 mg/l. The lakes and streams of the upper watershed showed no visible increase in turbidity during the year.

The Iron River (site 12) and the Hatchery site (site 21) on the other hand showed dramatic increases in solids levels during periods of heavy rainfall. Levels could increase rapidly from background concentrations of 1-2 mg/l to concentrations above 20 mg/l. The highest NFR level reported concurred with the thaw and heavy rainfall of late December 1983. This event resulted in measured NFR levels of 81 mg/l and 139 mg/l at site 21 on January 4, 1984. Both the Iron River and the lower Quinsam River showed obvious and sudden increases in turbidity in response to storm events.

Water temperatures were also measured with each sample. Continuous monitoring was also carried out at a number of sites. Mean daily values are summarized in Tables 31 to 37.

Summer water temperatures this year tended to be lower than normal due to the wet, cool weather in July. Since water temperatures have been measured at the Hatchery (site 21) for a number of years, this site was used for comparison with previous years. In 1983 the average daily temperature at site 21 over the last week of July was 17.4° C. In comparison, the average daily temperature for the previous 5 years ranged between 18.6° C and 19.4° C. These data suggest that the temperatures recorded at the upper site this year may have been significantly lower than normal.

It should be emphasized that higher temperatures might adversely affect other water quality parameters. For example, a strong negative correlation was noted between % oxygen saturation "02(%)" and water temperature "T" at the outlet of Flume Lake (site 8, Table 28). This area was heavily utilized by coho and discharges to a large swamp area at the head end of Middle Quinsam Lake.

The dissolved oxygen level (02 (%)) was related to temperature "T" by the following linear regression relationship:

$$02(\%) = 112.8 - 2.54T \quad \text{(see Fig. 18)}$$

There was a statistically significant relationship between these variables (at the 0.01 level). Twenty pairs of data collected between March 24 and August 12, 1983 were involved in this relationship and the correlation coefficient was -0.912. At

a temperature of 24° C (a possible summer water temperature for shallow surface waters of Vancouver Island) this relationship predicts that oxygen levels would drop to 52% (or 4.3 mg/l).

"Broad spectrum" water analysis was carried out at the Hatchery site (site 21). Results for the twelve samples spanning 1983 are shown in Table 23. The mean total alkalinity and dissolved water hardness were 19.3 mg/l (SD = 5.3) and 21.0 mg/l (SD = 5.7) respectively. These parameters increased in the summer months and fell to a minimum during the winter. Dissolved heavy metals remained below the detection limits over the entire period (Zn < 2 ug/l, Cu < 1 ug/l, Cd < 0.5 ug/l and Pb < 1 ug/l). Also, ammonia-N concentrations remained below 14 ug/l over the year.

3.4. Water Flows

Water flows were measured routinely at six sites over the study period. These measurements have been used to calibrate the staff gauges that have been established at each site. Discharge measurements (cms) and their corresponding gauge heights are shown in Tables 4 to 9.

Calibration curves were established at sites where flows varied over a fairly wide range (eg. see Outlet of Long Lake, Fig. 6). Other sites (eg. site 7, Fig. 10) require more data. Existing data has been plotted in Figures 5 to 10.

Curves have been fitted mathematically to the data. These relationships were obtained using a curve fitting program in conjunction with an Apple micro-computer (M. Austin, pers. comm.). The formulas relating water flow "y" (cms) to gauge height "x" (meters) and the range of gauge heights over which they are valid are shown below:

Site		Relationship	Range of "x" (m)
5	Long Lk	$y = 3.2/(1 + 0.1903x^{-4.3068})$	$0.18<x<0.739$
3	No-Name	$y = 5.794\ x^2 - 3.1173x + 0.4241$	$0.27<x<0.88$
10	Out MQL	$y = 14.4866x^2 - 8.2055x + 1.4403$	$0.44<x<1.42$
21	Q. Riv	$y = 24.3746x^2 - 6.2953x + 0.2729$	$0.40<x<1.158$
12	Iron	$y = 24.0453x^2 - 17.6675x + 3.0386$	$0.534<x<0.872$
7	In MQL	$y = 24.2284x^2 - 20.3197x + 4.6983$	$0.478<x<1.173$

The discharge curves (or their equations) allow gauge readings to be translated into water flow values. These calculated flow rates have been plotted over the study period for each site (Fig. 11 to 16). The values were not extrapolated below the measurement range - hence some of the gauge readings taken during extremely low flow periods could not be converted to flow values. These points are indicated by open circles in the figures. Gauge readings used to generate Figures 11 to 16 were

collected by Department of Fisheries and Oceans and by Quinsam Coal Co. Ltd. personnel. It should be cautioned that as more flow data is collected the calibration curves and the calculated flow values will change.

Extreme low flows occurred between late spring and early autumn. Minimum flows and the times at which they occurred are shown below for each site:

Site		Date, 1983	Low Flow (cms)
5	Long Lk	June 3-10, Aug 16 - Sep 9, Oct 14	< 0.01
3	No-Name	Aug 26 - Sep 2	< 0.0048
10	Out MQL	Aug 12, Aug 23	< 0.63
21	Q Riv	Jul 27 - Aug 29	< 1.65
12	Iron	June 16, Jul 7, Jul 28 - Oct 8	< 0.46
7	In MQL	June 3, June 17	< 0.52

It is clear that the Long Lake system has little capacity to dilute effluent. These data show that the discharge can be very low for extended time periods. In fact, flows in this system were less than 0.01 cms (0.35 cfs) for the 25 day period between August 16 and September 9. Even at the peak of the coho smolt migration (May 5 to May 25) the water flow averaged only 0.052 cms (1.84 cfs).

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Table 1. Quinsam Watershed coho colonization data (see Fig. 2 for area locations).

	Brood Years					
	1977	1978	1979	1980	1981	1982
Area						
1	42200	60000	10000	30000	15000	9524
2	0	0	0	15000	5000	14760
3	0	0	0	0	10000	23398
4	0	12000	5000	10000	18000	32320
5	150000	72000	25000	37000	15000	22293
6	0	74665	120000	140000	140000	80100
7	0	24000	0	10000	5000	35208
8	7285	0	40000	54060	40000	24922
Total	199985	242665	200000	296060	248000	242525
Fish Wts. (g)	7.9	4.8	8.3	10.3	10.0	10.5
Plant Date	03/10 1978	13-18/09 1979	09-10/09 1980	10-11/09 1981	15-17/09 1982	07-08/09 1983
Smolt Migrat'n	Spring 1979	Spring 1980	Spring 1981	Spring 1982		
No.	32831	58067	40540	40542		
% Survival to Smolt	16.4	23.9	20.3	13.7		

Table 2. Quinsam Watershed steelhead colonization summary.

Brood Year	Total Number of Steelhead	Fish Wts. (g)
1977	0	
1978	28671	1.75
1979	16496	8.3
1980	10246	6.0
1981	28300	9.0
1982	48080	5.1
1983	39000	5.0

* Steelhead fry were planted with coho fry in Areas 1-8

Table 4. Discharge and staff gauge height for Outlet of No-Name Lake (site 3).

Date	Gauge Height (meters)	Measured Flow cms
Jun 07/83	.27	.005
Jun 20	.295	.009
Jul 12	.494	.292
Jul 25	.350	.035
Aug 09	.29	.008
Nov 22	.595	.691
Nov 29	.62	.654

Table 5. Discharge and staff gauge height for Outlet of Long Lake (site 5).

Date	Gauge Height (meters)	Measured Flow cms
Feb 24/83	.625	1.17
Mar 02	.482	.463
Mar 03	.458	.488
Mar 07	.442	.527
Mar 17	.580	1.265
Mar 23	.412	.268
Apr 13	.351	.222
Apr 26	.305	.16
May 05	.299	.12
May 09	.287	.095
May 25	.214	.012
Jun 15	.180	.012
Jun 20	.198	.012
Jul 07	.287	.063
Jul 12	.384	.273
Jul 25	.287	.0815
Nov 18	.739	1.86 *
Nov 22	.579	.923
Nov 29	.603	1.139

* Norecol Data

Table 6. Discharge and staff gauge height for Outlet of Middle Quinsam Lake (site 10).

Date	Gauge Height (meters)	Measured Flow cms
Mar 02/83	-	1.56
Mar 07	-	1.36
Mar 16	-	4.43
Mar 23	-	1.12
Apr 13	-	1.20
Apr 26	-	1.08
May 05	-	.838
May 09	-	.685
May 12	-	.606
May 19	.450	.779
May 27	.440	.530
Jun 20	.442	.647
Jul 12	.500	.973
Nov 18	1.42	19 *
Nov 29	.66	2.325

Table 7. Discharge and staff gauge height for Quinsam River at Hatchery (site 21).

Date	Gauge Height (meters)	Measured Flow cms
Apr 13/83	.549	4.26
Apr 27	.595	5.06
May 06	.549	4.56
May 11	.492	3.28
May 18	.467	2.98
Jun 09	.400	1.68
Jul 26	.412	1.62
Nov 25	.869	13.43
Dec 07	.549	3.74
Dec 19	.579	4.30

* Norecol Data

Table 8. Discharge and staff gauge height for Iron River (site 12).

Date	Gauge Height (meters)	Measured Flow cms
Jun 01/83	.610	1.25
Jun 21	.533	.445
Nov 19	.872	5.92
Nov 23	.685	2.19

Table 9. Discharge and staff gauge height for Inlet to Middle Quinsam Lake (site 7).

Date	Gauge Height (meters)	Measured Flow cms
Mar 03/83	.519	.587
Mar 17	.519	.676
Mar 23	.519	.745
Apr 27	.533	.79
May 05	.487	.544
May 09	.484	.543
May 25	.484	.57
Jun 20	.484	.523
Nov 18	1.17	14.2 *
Dec 09	.483	.58

* Norecol Data

Table 10. Results of Gee minnow trapping program carried out between March 8 and April 23, 1983. The total number of coho captured and a summary of the fork length measurements are shown.

Sample Area	Date	Total Capt.	Sample (n)	Avg. Lgth. (cm) Nose-Fork	Range (cm) Min.	Max.
# 2 No-Name Lake	12/03/83	18	18	12.13	11.2	13.3
# 4 Long Lake	11/03/83	102	72	11.66	9.5	13.2
# 6 Flume Lake	17/03/83	98	30	10.78	8.6	12.7
# 8 Flume Lake Drainage	08/03/83	28	0			
# 9 Middle Quinsam Lake	16/03/83	13	7	11.73	10.3	13.1
#11 Quinsam River: 4 km below Outlet of Middle Quinsam Lake	17/03/83	42	42	9.68	8.1	11.7
#12 Iron River	15/04/83	30	27	8.99	7.4	10.5
#13 Drainage between Echo Lake & Lower Quinsam Lake	18/03/83	45	45	10.18	8.5	11.8
#14 Lower Quinsam Lake	18/03/83	2	2	9.65	8.4	10.9
#15 Unnamed Tributary (see map)	22/04/83	36	36	9.39	7.2	11.7
#16 Quinsam River Powerlines .8 km upstream of E.R.T. bridge	20/04/83	20	7	9.61	8.1	10.7
#18 South Branch Tributary #17	19/04/83	54	54	8.67	6.7	11.2
#19 North Branch Tributary #17	19/04/83	11	11	10.29	9.3	11.9
#20 Unnamed Tributary (see map)	20/04/83	2	2	10.25	9.9	10.6

Areas #3, #7, #17, #21 were not trapped.
Areas #1, #5, #10 were trapped with no results.

Table 11. Gee minnow trapping results for steelhead. Total numbers captured and fork length measurements are shown.

Sample Area	Date	Total Capt.	Sample (n)	Avg. Lgth. (cm) Nose-Fork	Range (cm) Min.	Max.
# 2 No-Name Lake	10/03/83	2	2	12.6	12.1	13.1
# 9 Middle Quinsam Lake	16/03/83	4	4	9.63	7.9	10.6
#10 Below Outlet of Middle Quinsam Lake (20 m)	22/03/83	34	34	8.2	5.6	9.9
#11 Quinsam River: 4 km below Outlet of Middle Quinsam Lake	17/03/83	73	73	8.68	6.5	13.0
#12 Iron River	15/04/83	35	35	10.69	5.6	15.6
#14 Lower Quinsam Lake	18/03/83	1	1	13.0	13.0	
#15 Unnamed Tributary (see map)	22/04/83	1	1	14.3	14.3	
#16 Quinsam River Powerlines .8 km upstream of E.R.T. bridge	20/04/83	35	35	8.99	18.5	6.5
#18 South Branch Tributary #17	19/04/83	1	1	14.2	14.2	

Areas #17 and #21 were not trapped.
Areas #1, #3, #4, #5, #6, #7, #8, #13, #19, #20 were trapped with with no results.

Table 12. Steelhead marks recovered during the Gee minnow trapping program.

Sample Area	Date	LM	RM	AD	UN	Total
# 2 No-Name Lake	10/03/83	2	0	0	0	2
# 9 Middle Quinsam Lake	16/03/83	1	3	0	0	4
#10 Below Outlet of Middle Quinsam Lake (20 m)	22/03/83	18	16	0	0	34
#11 Quinsam River: 4 Km below Outlet of Middle Quinsam Lake	17/03/83	36	0	0	37	73
#12 Iron River	15/04/83	1	0	0	34	35

Type of Mark

LM - Left Maxillary Clip (river released)
RM - Right Maxillary Clip (lake released)
AD - Adipose Clip (1979+1980 release)
UN - Unmarked

Table 13. Gee minnow trapping results for cutthroat. Total numbers captured and fork length measurements are shown.

Sample Area	Date	Total Capt.	Sample (n)	Avg. Lgth. (cm) Nose-Fork	Range (cm) Min.	Range (cm) Max.
# 2 No-Name Lake	10/03/83	3	3	14.33	11.1	19.0
# 6 Flume Lake	17/03/83	4	4	18.03	15.4	21.4
# 9 Middle Quinsam Lake	16/03/83	4	4	10.15	9.4	11.9
#11 Quinsam River: 4 km below Outlet of Middle Quinsam Lake	17/03/83	4	4	9.50	8.0	11.5
#13 Drainage between Echo Lake & Lower Quinsam Lake	18/03/83	12	12	11.66	9.1	14.0
#14 Lower Quinsam Lake	18/03/83	1	1	10.1	10.1	
#15 Unamed Tributary (see map)	22/04/83	3	3	12.47	11.2	14.7
#18 South Branch Tributary #17	18/04/83	1	1	11.8	11.8	
#20 Unamed Tributary (see map)	20/04/83	11	11	11.75	8.5	14.9

Areas #17 and #21 were not trapped.
Areas #1, #3, #4, #5, #7, #8, #10, #12, #16, #19 were trapped with no results.

Table 14. Summary of the numbers of fish by species and by area captured in the minnow trapping program (March 8 - April 22, 1983).

Sample Area	Coho	Sthd	Cutt	Dlvd	Scpn	Stbk
# 2 No-Name Lake	18	2	3	0	2	0
# 4 Long Lake	102	0	0	0	3	0
# 6 Flume Lake	98	0	4	0	2	0
# 8 Flume Lake Drainage	28	0	4	0	1	0
# 9 Middle Quinsam Lake	7	4	10	0	11	0
#10 Below Outlet of Middle Quinsam Lake (20 m)	0	35	4	0	1	0
#11 Quinsam River: 4 Km below Outlet of Middle Quinsam Lake	42	73	4	0	4	7
#12 Iron River	30	56	0	6	22	1
#13 Drainage between Echo Lake & Lower Quinsam Lake	45	0	12	0	0	0
#14 Lower Quinsam Lake	2	1	1	0	0	2
#15 Unamed Tributary (see map)	38	1	3	0	0	1
#16 Quinsam River Powerlines .8 Km upstream of E.R.T. bridge	20	35	0	0	0	4
#18 South Branch Tributary #17	55	1	1	0	0	8
#19 North Branch Tributary #17	11	0	0	0	0	0
#20 Unnamed Tributary (see map)	2	0	11	0	0	0

Areas #3, #7, #17, #21 were not trapped.
Areas #1, #5 were trapped with no results.

Species
Coho - Coho
Sthd - Steelhead
Cutt - Cutthroat
Dlvd - Dolly Varden
Scpn - Sculpins
Stbk - Stickleback

Table 15. Number of cutthroat trout captured in the "downstream trap" located near the Outlet of Long Lake (April 18 - June 1, 1983). The numbers of fish over 10 cm, under 10 cm and the numbers of fry are also indicated.

Date	Daily Capt.	Cumm. Daily	Size		Fry
			Over 10 cm	Under 10 cm	
April 22/83	1	1	1	-	-
23	1	2	1	-	-
24	3	5	3	-	-
25	1	6	1	-	-
26	1	7	1	-	-
27	0	7	-	-	-
28	2	9	2	-	-
29	5	14	5	-	-
30	1	15	1	-	-
May 1	0	15	-	-	-
2	0	15	-	-	-
3	2	17	2	-	-
4	0	17	-	-	-
5	0	17	-	-	-
6	5	22	1	4	-
7	1	23	-	1	-
8	3	26	-	3	-
9	4	30	1	3	-
10	4	34	1	3	-
11	6	40	-	6	-
12	1	41	-	1	-
13	0	41	-	-	-
14	2	43	-	-	2
15	0	43	-	-	1
16	1	44	-	-	-
17	0	44	-	-	-
18	3	47	-	-	3
19	4	51	-	4	-
20	0	51	-	-	-
21	0	51	-	-	-
22	0	51	-	-	-
23	0	51	-	-	-
24	0	51	-	-	-
25	0	51	-	-	-
26	0	51	-	-	-
27	0	51	-	-	-
28	0	51	-	-	-
29	0	51	-	-	-
30	0	51	-	-	-
31	0	51	-	-	-
June 1	0	51	-	-	-

Trap removed on June 1, 1983.

Table 16. Daily migration of coho smolts out of Long Lake (April 18 and June 1, 1983). The daily capture rate has been multiplied by the catch coefficient to obtain an estimate of the daily migration.

Date	Daily Capture	Cumm. Daily Capture	Catch Coefficient	Estimated Daily Migration	Estimated Cumm. Population
April 18/83	2	2	3.52	7	7
19	3	5	3.52	11	18
20	78	83	3.52	275	292
21	8	91	3.52	28	320
22	2	93	3.52	7	327
23	6	99	3.52	21	348
24	14	113	3.52	49	398
25	1	114	3.52	4	401
26	24	138	3.52	84	486
27	72	210	3.52	253	739
28	63	273	3.52	222	961
29	289	562	3.52	1017	1978
30	38	600	3.52	134	2112
May 1	49	649	3.52	172	2284
2	28	677	3.52	99	2383
3	56	733	3.52	197	2580
4	53	786	3.52	187	2767
5	50	846	3.52	176	2943
6	170	1006	3.52	598	3541
7	16	1022	3.52	56	3597
8	338	1360	3.52	1190	4787
9	188	1548	3.52	662	5449
10	124	1672	3.52	436	5885
11	306	1978	3.52	1077	6963
12	358	2336	3.52	1260	8223
13	143	2479	8.88	1270	9493
14	36	2515	8.88	320	9812
15	101	2616	8.88	897	10709
16	84	2700	8.88	746	11455
17	26	2726	8.88	231	11686
18	279	3005	8.88	2478	14163
19	200	3205	8.88	1776	15939
20	26	3231	8.88	231	16170
21	5	3236	8.88	44	16215
22	12	3248	8.88	107	16321
23	9	3257	8.88	80	16401
24	0	3257	8.88	0	16401
25	0	3257	8.88	0	16401
26	0	3257	8.88	0	16401
27	0	3257	8.88	0	16401
28	0	3257	8.88	0	16401
29	0	3257	8.88	0	16401
30	0	3257	8.88	0	16401
31	0	3257	8.88	0	16401
June 1	0	3257	8.88	0	16401

Table 17. Fork length of steelhead captured in the "downstream trap" located at the Outlet of Middle Quinsam Lake. Mark type is also indicated.

Date		Adipose	L. Maxillary	R. Maxillary	Size (cm)
May	07/83	0	1	0	19.1
	17	0	1	0	21.3
	18	1	0	0	18.6
	18	0	1	0	19.6
	18	0	1	0	13.3
	18	0	1	0	18.7
	18	0	1	0	17.6
	18	0	1	0	18.9
	18	0	0	1	17.8
	19	0	0	1	13.5
	19	0	1	0	20.3
	19	0	1	0	17.8
	19	0	1	0	17.6
	19	1	0	0	18.6
	20	0	1	0	18.4

Table 18. Daily migration of coho smolts out of Middle Quinsam Lake (April 15 - June 1, 1983). The daily migration has been estimated by multiplying the daily capture rate by the catch coefficient.

Date		Daily Capt.	Cumm. Capt.	Catch Coefficient	Estimated Daily Mig.	Estimated Cumm. Pop
April	15/83	4	4	25.58	102	102
	16	0	4	25.58	0	102
	17	0	4	25.58	0	102
	18	0	4	25.58	0	102
	19	26	30	25.58	665	767
	20	22	52	25.58	563	1330
	21	3	55	25.58	77	1407
	22	1	56	25.58	26	1433
	23	6	62	25.58	153	1586
	24	2	64	25.58	51	1637
	25	13	77	25.58	333	1970
	26	15	92	25.58	384	2354
	27	23	115	25.58	588	2942
	28	70	185	25.58	1791	4733
	29	149	334	25.58	3811	8544
	30	109	443	25.58	2788	11332
May	1	106	549	25.58	2711	14043
	2	93	642	25.58	2379	16422
	3	103	745	25.58	2635	19057
	4	140	885	25.58	3581	22638
	5	166	1051	25.58	4246	26884
	6	37	1088	25.58	946	27830
	7	94	1182	25.58	2405	30235
	8	42	1224	25.58	1074	31309
	9	81	1305	25.58	2072	33381
	10	89	1394	25.58	2277	35658
	11	98	1492	25.58	2507	38165
	12	102	1594	25.58	2609	40774
	13	71	1665	25.58	1816	42590
	14	27	1692	25.58	691	43281
	15	20	1712	25.58	512	43793
	16	15	1727	25.58	384	44177
	17	31	1758	25.58	793	44970
	18	23	1781	25.58	588	45558
	19	11	1792	25.58	281	45839
	20	12	1804	25.58	307	46146
	21	6	1810	25.58	153	46299
	22	3	1813	25.58	77	46376
	23	1	1814	25.58	26	46402
	24	0	1814	25.58	0	46402
	25	0	1814	25.58	0	46402
	26	0	1814	25.58	0	46402
	27	0	1814	25.58	0	46402
	28	2	1816	25.58	51	46453
	29	0	1816	25.58	0	46453
	30	0	1816	25.58	0	46453
	31	0	1816	25.58	0	46453
June	1	0	1816	25.58	0	46453

Table 19. Cutthroat trout captured in the "downstream trap" located at the Outlet of Middle Quinsam Lake (April 15 - June 1, 1983).

Date	Daily Capt.	Cumm. Daily	Size		
			Over 10 cm	Under 10 cm	Fry
April 22/83	2	2	2	-	-
23	1	3	1	-	-
24	1	4	1	-	-
25	0	4	-	-	-
26	0	4	-	-	-
27	0	4	-	-	-
28	2	6	2	-	-
29	0	6	-	-	-
30	2	8	2	-	-
May 1	0	8	-	-	-
2	0	8	-	-	-
3	5	13	5	-	-
4	1	14	-	-	1
5	3	17	-	1	2
6	2	19	-	2	-
7	4	23	-	4	-
8	1	24	-	1	-
9	0	24	-	-	-
10	2	26	1	1	-
11	3	29	-	3	-
12	3	32	2	1	
13	1	33	-	-	1
14	2	35	-	-	2
15	0	35	-	-	-
16	1	36	-	-	1
17	0	36	-	-	-
18	2	38	-	-	2
19	1	39	-	1	-
20	0	39	-	-	-
21	1	40	-	1	-
22	0	40	-	-	-

Trap removed on June 1, 1983.

Table 20. Steelhead captured in the "downstream trap" located at the Outlet of Middle Quinsam Lake (April 15 - June 1, 1983). Mark type is indicated.

Date	Adipose Clips	Daily Capture	Marks in Recapture	Cumm. Total	Cumm. Count Left	Cumm. Count Right
April 20/83		1	1 Left Max.	1	1	0
21		1	1 Right Max.	2	1	1
22		1	1 Left Max.	3	2	1
23		0		3	2	1
24		1	1 Right Max.	4	2	2
25		0		4	2	2
26		0		4	2	2
27		1	1 Right Max.	5	2	3
28		2	1 Left Max.	7	3	4
			1 Right Max.			
29		1	1 Left Max.	8	4	4
30		1	1 Right Max.	9	4	5
May 1		0		9	4	5
2		0		9	4	5
3		1	1 Right Max.	10	4	6
4		1	1 Left Max.	11	5	6
5		1	1 Left Max.	12	6	6
6		0		12	6	6
7		1	1 Left Max.	13	7	6
8		0		13	7	6
9		0		13	7	6
10		0		13	7	6
11		0		13	7	6
12		0		13	7	6
13		0		13	7	6
14		0		13	7	6
15		0		13	7	6
16		0		13	7	6
17		1	1 Left Max.	14	8	6
18	1*	7*	5 Left Max.			
			1 Right Max.			
19	1*	5*	3 Left Max.			
			1 Right Max.			
20		1*	1 Left Max.			

* These fish were captured in the 100% trap not in the regular trapping panel.

Table 21. Trap efficiency evaluation at Outlet of Middle Quinsam Lake, May 18, 19 and 20, 1983.

Date	Fish Captured in Downstream Trap	Total Downstream Migration	Trap Efficiency %
May 18/83	25	538	4.647
May 19/83	12	360	3.333
May 20/83	12	321	3.738

Average Trap Efficiency = 3.91%
Catch Coefficient = 25.58

Table 22. Trap efficiency evaluation at Outlet of Long Lake, April 20, May 4, 13 and 17, 1983.

Date	No. of Coho Marked for Recapture	Type of Mark	No. of Coho Recaptured	Trap Eff.%	Catch Coeff.
April 20/83	72	Left Ventral			
May 04/83	97	Left Ventral	48	28.4	3.52
Total	169				
May 13/83	127	Silver Staples	19		
May 17/83	104	Red, White, Green Staples	7		
Total	231		26	11.3	8.88

Table 23. Water analysis performed at the D.F.O. lab in West Vancouver for site 21 (Quinsam River at Hatchery). Metal values have been averaged over samples taken in duplicate. Both extractable (EXT) and dissolved values (DISS) metal concentrations are shown.

	Jan 17	Feb 15	Mar 16	Apr 12	May 4	Jun 7	Jul 19	Aug 10	Sep 13	Oct 18	Nov 21	Dec 13
pH	7.0	7.4	7.3	7.6	7.6	7.4	7.3	7.3	7.2	7.3	6.8	6.9
T. ALK (mg/1)	15.5	13.0	15.0	19.5	21.5	25.0	22.0	28.0	23.0	23.5	13.5	12.0
T.PO4-P (ug/1)	<7	29	11	-	7	6	7	<5	6	7	14	16
O.PO4-P (ug/1)	<5	12	<5	-	<5	-	-	<5	<5	<5	4	2
Nitrite-N (ug/1)	<5	6	<5	<5	<5	<5	-	9	<5	<5	<5	<5
Nitrate-N (ug/1)	90	60	60	60	10	20	<10	<10	<10	10	90	40
Ammonia-N (ug/1)	8	7	6	<5	5	6	<5	<5	8	7	12	14
T. HARD (mg/1)												
EXT.	16.6	18.3	15.8	19.2	22.3	25.2	27.0	30.2	26.9	26.7	18.1	18.7
DISS.	15.5	13.7	14.9	18.9	22.1	24.9	26.8	29.9	26.4	26.4	16.3	16.5
CD (ug/1)												
EXT.	<.5	<.5	<.5	<.5	<.5	<.5	<.5	<.5	<.5	<.5	<.5	<.5
DISS.	<.5	<.5	<.5	<.5	<.5	<.5	<.5	<.5	<.5	<.5	<.5	<.5
CU (ug/1)												
EXT.	<1	2	<1	<1	<1	<1	<1	<1	<1	2	<1	2
DISS.	<1	1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
PB (ug/1)												
EXT.	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
DISS.	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
ZN (ug/1)												
EXT.	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
DISS.	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
HG (ug/1)												
EXT.	<50	<50	<50	<50	-	-	-	-	-	-	-	-
DISS.	<50	<50	<50	<50	-	-	-	-	-	-	-	-

Table 23 (cont'd)

	Jan 17	Feb 15	Mar 16	Apr 12	May 4	Jun 7	Jul 19	Aug 10	Sep 13	Oct 18	Nov 21	Dec 13
FE (mg/1)												
EXT.	.146	.513	.205	.135	.115	.114	.113	.115	.121	.118	.255	.389
DISS.	.069	.091	.061	.099	.084	.091	.086	.087	.065	.092	.084	.151
MG (mg/1)												
EXT.	.80	.70	.70	1.0	1.0	1.2	1.2	1.5	1.2	1.3	.80	1.2
DISS.	.75	.65	.70	1.0	1.0	1.1	1.2	1.5	1.2	1.3	.80	1.1
CA (mg/1)												
EXT.	4.9	4.4	4.7	5.8	7.1	.80	8.8	9.5	8.6	8.5	5.1	4.5
DISS.	4.8	4.2	4.7	5.7	7.1	.80	8.8	9.5	8.6	8.4	5.1	4.4
AL (mg/1)				*.07 (Duplicate Sample)								
EXT.	.13	.59	.16	<.05	<.05	<.05	<.05	<.05	<.05	<.05	.26	.35
DISS.	<.05	.10	.06	<.05	<.05	<.05	<.05	<.05	<.05	<.05	.06	.11
MN (mg/1)												
EXT.	.007	.025	.010	.005	.005	.005	.004	.005	.006	<.001	.013	.020
DISS.	.004	.005	.004	.004	.003	.003	.002	.003	.002	<.001	.004	.008
NA (mg/1)												
EXT.	1.2	.10	1.2	1.7	1.5	1.8	1.7	2.3	1.6	1.8	1.1	1.9
DISS.	1.2	.10	1.2	1.7	1.5	1.8	1.7	2.2	1.6	1.8	1.1	1.9
FR (mg/1)	46	27	28	42	32	51	40	43	40	47	48	50
NFR (mg/1)	<5	32	6	8	<5	<5	<5	<5	<5	<5	8	14
K (mg/1)												
EXT.	.11	.17	.09	.13	.08	.141	.134	.187	.144	.182	.146	.165
DISS.	.11	.12	-	.12	.08	.141	.132	.182	.142	.187	.128	.151
SULFATE (mg/1)	2.8	2.4	3.0	3.2	2.8	3.1	3.8	3.6	3.4	5.0	4.1	2.5
CHLORIDE (mg/1)	1.2	1.3	1.1	1.9	1.0	1.98	.9	1.9	1.3	3.0	1.1	2.3
CONDUCT (umhos/cm)	38.3	33.4	36.8	45.2	50.2	60.0	56.8	69.2	54.1	64.1	36.4	40.9
SILICA (mg/1)												
EXT.	3.0	2.7	2.8	3.3	2.2	2.5	2.6	2.4	2.1	-	3.1	4.0
DISS.	-	-	-	-	-	-	-	-	-	2.4	2.8	3.7

FR = Filterable Residue (dissolved solids)
NFR = Non-filterable Residue (suspended solids)

Table 24. Water sampling data for Outlet of No-Name Lake (site 3), 1983.

Date	Temp °C	DO (mg/l)	pH	NFR (mg/l)	Oxygen % Saturat.
Mar 24	7.6	11.7	6.81	-	101.12
Mar 31	6.5	11.2	6.85	-	94.18
Apr 08	8.0	11.2	6.90	-	97.76
Apr 15	11.5	10.8	7.06	-	102.48
Apr 22	11.8	10.0	7.09	-	95.54
Apr 29	14.2	9.4	7.18	-	94.80
May 05	15.2	8.9	7.10	-	91.73
May 12	15.1	8.9	7.53	-	91.54
May 19	17.0	8.4	7.37	-	89.96
Jun 03	18.9	8.5	7.14	-	94.65
Jun 10	19.2	8.8	7.43	-	98.58
Jun 17	17.1	8.9	7.33	-	95.51
Jun 24	16.8	8.8	7.42	-	93.85
Jun 30	17.7	8.7	7.39	-	94.53
Jul 08	17.2	9.2	7.36	-	98.94
Jul 15	16.3	8.6	7.13	-	90.75
Jul 22	18.2	8.1	7.43	-	88.92
Jul 29	18.3	8.3	7.12	-	91.30
Aug 03	19.1	8.0	7.34	-	91.30
Aug 12	19.9	8.1	7.17	-	89.44
Aug 26	18.2	8.4	7.02	-	91.71
Sep 02	17.1	8.1	7.38	-	86.56
Sep 16	15.6	8.9	7.10	-	93.00
Nov 15	-	-	-	<1.0 *	-
Nov 16	6.3	-	7.15	0.3	-
Nov 18	-	-	-	0.2	-
Nov 24	-	-	-	0.1	-
Dec 14	1.4	-	-	<0.1	-
Dec 23	2.5	12.7	7.09	-	95.85
Mean		9.28	7.20		93.92
SD		1.29	0.19		3.91

DO = Dissolved Oxygen
* Norecol Data

Table 25. Water sampling data for Outlet of Long Lake (site 5), 1983.

Date	Temp °C	DO (mg/1)	pH	NFR (mg/1)	Oxygen % Saturat.
Mar 24	7.5	11.8	7.03	-	101.49
Mar 31	6.5	11.7	7.02	-	98.14
Apr 08	8.0	11.3	6.93	-	98.39
Apr 15	10.0	10.9	7.10	-	99.61
Apr 22	11.1	10.6	7.15	-	99.41
Apr 29	14.2	9.7	7.22	-	97.58
May 05	14.5	9.1	7.29	-	92.15
May 12	13.3	8.9	7.24	-	87.76
May 19	15.9	8.5	7.10	-	88.72
Jun 03	17.6	7.3	7.02	1.0	78.97
Jun 10	16.4	7.5	7.09	1.0	79.12
Jun 17	16.5	8.1	7.19	0.5	85.63
Jun 24	16.0	8.6	7.14	0.5	89.96
Jun 30	16.7	8.5	7.28	0.7	90.24
Jul 08	17.6	8.6	7.32	0.7	93.15
Jul 15	16.9	8.7	7.16	0.6	92.75
Jul 22	18.4	8.2	7.13	1.1	90.17
Jul 29	18.1	8.1	7.10	0.9	88.52
Aug 03	18.5	7.9	7.23	0.7	87.05
Aug 12	19.3	7.5	7.03	0.6	83.98
Aug 26	18.0	7.9	7.06	0.8	85.15
Sep 02	16.5	7.3	7.20	0.8	77.04
Sep 16	15.6	8.6	7.20	0.7	89.70
Nov 15	-	-	-	<1.0 *	-
Nov 16	6.4	-	7.26	0.4	-
Nov 24	-	-	-	0.3	-
Dec 18	1.2	-	-	3.3	-
Dec 23	2.2	13.1	7.33	-	98.34
Mean		9.10	7.15		90.54
SD		1.61	0.11		6.90

* Norecol Data

Table 26. Water sampling data for Outlet of Middle Quinsam Lake (site 10), 1983.

Date	Temp °C	DO (mg/l)	pH	NFR (mg/l)	Oxygen % Saturat.
Mar 24	7.2	11.9	7.18	-	99.64
Mar 31	7.0	11.8	7.01	-	100.19
Apr 08	9.0	11.1	7.45	-	99.00
Apr 15	10.0	11.1	7.30	-	101.4
Apr 22	11.8	10.6	7.34	-	100.99
Apr 29	15.1	9.8	7.36	-	100.51
May 05	14.8	9.2	7.59	-	93.74
May 12	13.5	9.0	7.60	-	89.11
May 19	18.0	8.7	7.51	-	94.85
Jun 03	19.0	6.9	7.43	0.6	76.77
Jun 10	18.5	8.5	7.55	0.5	93.62
Jun 17	17.0	8.9	7.60	0.8	95.04
Jun 24	16.9	9.0	7.49	0.4	95.91
Jun 30	18.0	8.7	7.46	0.5	94.85
Jul 08	17.4	9.1	7.41	0.3	97.99
Jul 15	17.1	8.6	7.28	0.9	92.03
Jul 22	-	8.3	-	0.4	-
Jul 29	19.0	8.2	7.24	0.3	91.23
Aug 03	19.7	8.2	7.21	0.3	92.52
Aug 12	22.0	8.4	7.21	0.5	99.12
Aug 26	20.9	7.8	7.21	0.8	90.11
Sep 02	19.4	8.3	7.23	0.8	92.71
Sep 16	14.9	8.7	7.51	0.4	88.95
Nov 15	-	-	-	<1.0 *	-
Nov 16	6.9	-	7.21	0.6	-
Nov 18	-	-	-	0.7	-
Nov 24	-	-	-	0.3	-
Dec 14	2.2	-	-	0.8	-
Dec 23	2.2	12.7	7.38	-	95.21
Mean		9.31	7.37		94.59
SD		1.46	0.16		5.48

* Norecol Data

Table 27. Water sampling data for Iron River (site 12), 1983.

Date	Temp °C	DO (mg/l)	pH	NFR (mg/l)	Oxygen % Saturat.
Mar 30	4.5	12.0	7.63	-	94.57
Apr 07	6.0	11.8	7.69	-	95.65
Apr 14	5.0	12.3	7.45	-	98.20
Apr 28	7.4	11.3	7.5	-	94.23
May 04	5.9	11.4	7.49	-	93.14
May 12	8.9	10.4	7.61	-	91.54
May 19	9.0	10.1	7.52	-	89.11
May 27	9.5	10.4	7.45	-	92.87
Jun 01	9.4	10.6	7.22	-	94.42
Jun 09	10.8	10.0	7.28	-	92.09
Jun 16	10.5	10.4	7.57	-	95.10
Jun 23	10.7	-	7.48	-	-
Jun 29	11.7	10.0	7.39	-	94.04
Jul 07	11.4	9.7	7.38	-	80.58
Jul 14	11.1	10.1	7.35	-	93.66
Jul 21	13.3	9.8	7.23	-	93.62
Jul 28	13.0	9.8	7.23	-	94.92
Aug 04	14.0	9.4	7.47	-	73.29
Aug 11	16.0	8.1	7.40	-	83.79
Aug 22	16.2	8.7	7.21	-	90.37
Sep 01	14.1	8.7	7.26	-	87.06
Sep 15	11.4	10.2	7.32	-	94.00
Nov 15	-	-	-	82.4 *	-
Mean		10.25	7.42		91.30
SD		1.08	0.14		5.85

* Norecol Data

Table 28. Water sampling data for the Culvert Outflow of Flume Lake (site 8), 1983.

Date	Temp °C	DO (mg/1)	pH	NFR (mg/1)	Oxygen % Saturat.
Mar 24	8.0	10.5	6.77	-	91.39
Mar 31	8.0	10.7	6.69	-	93.13
Apr 08	9.0	10.3	6.93	-	91.86
Apr 15	11.0	9.8	6.92	-	91.65
Apr 22	11.0	8.9	6.87	-	83.24
Apr 29	14.8	7.8	6.84	-	79.47
May 05	13.3	7.7	7.05	-	75.90
May 12	13.1	7.2	6.71	-	70.65
May 19	15.6	7.3	6.91	-	75.58
Jun 03	17.0	6.9	6.63	-	73.68
Jun 10	16.2	7.0	6.93	-	73.50
Jun 17	16.0	7.3	6.94	-	76.33
Jun 24	14.8	7.2	6.99	-	73.36
Jun 30	15.9	6.7	6.98	-	69.90
Jul 08	15.5	7.5	6.91	-	77.58
Jul 15	15.4	6.9	6.98	-	71.22
Jul 22	16.9	6.1	6.92	-	65.00
Jul 29	17.1	6.4	6.79	-	68.48
Aug 03	17.5	6.1	6.84	-	65.82
Aug 12	19.8	5.7	6.91	-	64.40
Aug 26	17.5	6.0	6.89	-	64.57
Sep 02	16.2	6.0	6.87	-	62.92
Sep 16	13.4	6.8	7.42	-	66.50
Nov 16	6.7	-	6.45	0.1	-
Nov 18	-	-	-	1.5	-
Nov 24	-	-	-	0.5	-
Dec 23	1.3	11.8	7.26	-	86.33
Mean		7.69	6.90		75.52
SD		1.71	0.19		9.58

Table 29. Water sampling data for Quinsam River at Hatchery (site 21), 1983.

Date	Temp °C	DO (mg/1)	pH	NFR (mg/1)	Oxygen % Saturat.
Jun 28	-	-	-	0.7	-
Jul 06	16.9	9.3	7.65	0.6	96.37
Jul 14	15.6	9.3	7.20	1.3	93.75
Jul 20	18.9	8.8	7.08	0.5	95.04
Jul 27	18.2	8.9	7.24	0.8	94.74
Aug 04	15.8	9.3	7.26	0.2	94.15
Aug 10	17.9	8.4	7.28	0.3	88.87
Aug 22	16.2	9.3	7.50	0.2	94.96
Sep 01	16.8	8.8	7.45	1.0	91.72
Sep 15	11.6	10.2	7.44	1.3	94.90
Nov 16	8.0	-	7.00	21.5	-
Nov 18	-	-	-	14.5	-
Nov 24	-	-	-	5.0	-
Dec 13	-	-	-	10.0	-
Mean		9.14	7.31		93.83
SD		0.51	0.20		2.25

Table 30. Water sampling data for Inlet of Middle Quinsam Lake (site 7), 1983.

Date	Temp °C	DO (mg/l)	pH	NFR (mg/l)	Oxygen % Saturat.
Mar 24	6.0	12.0	7.42	-	99.35
Mar 31	7.0	12.0	7.28	-	101.89
Apr 08	7.0	11.7	7.46	-	99.34
Apr 15	9.0	11.0	7.48	-	84.17
Apr 22	10.5	10.5	7.58	-	97.06
Apr 29	12.9	9.7	7.46	-	94.76
May 05	12.0	9.3	7.70	-	89.01
May 12	12.1	9.0	7.75	-	86.34
May 19	14.6	8.9	7.56	-	90.29
Jun 03	16.4	8.8	7.53	0.8	92.80
Jun 10	16.4	8.9	7.69	0.5	93.85
Jun 17	15.4	9.3	7.74	0.3	96.00
Jun 24	14.8	9.2	7.89	0.1	93.74
Jun 30	14.9	9.3	7.48	0.2	94.96
Jul 08	14.7	9.6	7.36	0.2	97.60
Jul 15	14.7	9.1	7.37	0.1	92.52
Jul 22	16.2	8.6	7.14	0.4	90.30
Jul 29	16.9	8.6	7.27	0.1	91.65
Aug 03	17.8	8.7	7.35	0.1	94.46
Aug 12	19.1	8.8	7.46	0.2	98.11
Aug 26	17.9	8.4	7.28	0.4	91.14
Sep 02	16.3	9.0	7.30	0.4	94.58
Sep 16	14.8	9.5	7.40	-	97.10
Nov 15	-	-	-	2.8 *	-
Nov 16	7.7	-	6.77	1.3	-
Nov 18	-	-	-	1.3	-
Nov 24	-	-	-	0.3	-
Dec 23	.5	14.2	7.56	-	101.64
Mean		9.75	7.45		94.28
SD		1.43	0.23		4.45

* Norecol Data

Table 31. Mean daily water temperature (°C) for Outlet of Long Lake (site 5), 1983.

Date	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1	-	15.0	18.9	17.3	20.0	17.0	12.4	-	4.9
2	-	14.5	17.9	17.0	19.9	16.3	12.2	-	4.7
3	-	14.2	17.6	17.0	18.8	17.0	12.4	-	-
4	-	15.0	17.7	17.4	19.1	17.0	11.9	-	-
5	-	14.2	17.5	17.7	19.3	15.0	11.5	-	-
6	-	14.0	17.4	17.3	19.5	15.3	11.6	-	-
7	-	13.0	17.5	17.3	20.0	15.1	10.9	-	3.0
8	8.0	13.0	17.0	17.6	20.2	14.4	-	-	3.8
9	8.2	13.5	16.8	17.9	20.1	13.7	-	-	3.6
10	8.7	15.2	16.4	17.5	20.2	14.5	-	-	3.4
11	9.0	14.8	16.5	17.2	20.7	16.1	-	-	3.5
12	9.0	13.3	16.8	17.2	20.3	16.0	-	-	3.2
13	9.0	13.3	17.0	17.8	20.2	16.5	-	-	3.1
14	9.5	13.5	17.2	17.5	19.7	16.6	-	-	3.4
15	10.0	14.5	17.5	17.3	19.3	16.2	-	6.7	3.6
16	10.3	15.2	17.4	18.2	19.3	16.2	-	7.1	3.5
17	10.9	14.9	16.5	19.0	19.5	15.1	-	6.8	3.5
18	11.3	13.0	17.5	19.3	18.6	15.0	9.1	6.7	3.5
19	12.7	15.9	17.4	19.6	18.1	14.7	9.9	6.8	3.4
20	12.3	17.2	17.2	19.2	17.5	14.9	9.8	6.7	3.5
21	11.7	17.8	16.8	19.2	17.3	15.2	10.1	6.5	3.6
22	11.1	17.8	16.5	19.5	17.4	15.4	-	6.6	3.4
23	11.5	18.0	16.6	20.0	17.7	15.5	-	6.4	3.3
24	12.0	18.6	16.0	20.4	17.3	15.2	-	6.1	3.3
25	11.7	19.9	16.9	20.3	17.0	15.0	-	6.0	3.1
26	12.0	19.0	17.1	19.1	16.3	14.4	-	6.0	3.0
27	13.0	17.0	17.5	18.9	16.3	12.8	-	5.8	2.8
28	14.0	17.6	17.5	19.1	16.4	12.5	-	5.6	2.7
29	14.2	18.3	17.7	19.2	15.1	12.3	-	5.4	2.5
30	14.3	19.4	17.3	19.7	15.8	12.1	-	5.2	2.5
31		20.0		20.5	16.6		-		2.5

Table 32. Mean daily water temperature (°C) for Outlet of No-Name Lake (site 3), 1983.

Date	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1	-	15.3	-	-	-	-	-	-	-
2	-	15.0	-	-	-	17.1	-	-	-
3	-	15.0	18.9	-	19.1	-	-	-	-
4	-	14.7	-	17.8	-	-	-	-	-
5	-	15.2	-	-	-	-	-	-	-
6	-	14.5	-	-	-	-	-	-	-
7	-	13.5	18.5	18.1	-	-	-	-	3.0
8	8.0	13.0	-	17.2	-	-	-	-	-
9	-	14.2	-	-	-	-	-	-	-
10	-	16.7	19.2	-	-	-	-	-	-
11	-	16.5	-	-	-	-	-	-	-
12	-	15.1	-	17.0	19.9	-	-	-	-
13	-	-	-	-	-	-	-	-	-
14	-	15.0	-	-	-	-	-	-	1.4
15	11.5	15.1	-	16.3	19.4	-	-	6.4	-
16	-	15.8	-	-	-	15.6	-	6.3	-
17	-	15.9	17.1	-	-	-	-	-	-
18	-	-	-	-	-	-	9.9	-	-
19	-	-	-	-	-	-	-	-	-
20	-	-	-	-	-	-	-	-	-
21	-	18.8	-	19.2	-	-	-	-	2.4
22	11.8	18.2	17.6	18.2	-	-	-	6.0	-
23	-	-	-	-	-	-	-	-	2.5
24	-	20.5	16.8	-	-	-	-	5.5	-
25	12.0	-	-	21.0	-	-	-	-	-
26	12.5	-	-	-	18.2	-	-	-	-
27	13.0	20.5	-	-	-	-	-	-	-
28	14.0	-	-	-	-	-	-	-	-
29	14.2	-	-	18.3	-	-	-	4.5	-
30	15.1	20.5	17.7	-	-	-	-	-	-
31		23.5		-	-		-		-

Table 33. Mean daily water temperature (°C) for Inlet to Middle Quinsam Lake (site 7), 1983.

Date	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1	-	12.9	-	-	-	-	-	-	-
2	-	12.7	-	-	-	16.3	-	-	-
3	-	12.0	16.4	-	17.8	-	-	-	-
4	-	12.0	-	15.2	-	-	-	-	-
5	-	12.0	-	-	-	-	-	-	-
6	-	12.0	-	-	-	-	-	-	-
7	-	11.4	-	-	-	-	-	-	3.7
8	7.0	11.0	-	14.7	-	-	-	-	-
9	-	11.5	-	-	-	-	-	-	4.0
10	-	12.7	16.4	-	-	-	-	-	-
11	7.5	12.8	-	-	-	-	-	-	-
12	-	12.1	-	-	19.1	-	-	-	-
13	-	-	16.0	-	-	-	-	-	-
14	-	12.8	-	-	-	-	-	-	-
15	9.0	12.7	16.7	14.7	-	-	-	7.5	-
16	-	12.8	-	-	-	14.8	-	7.7	-
17	-	-	15.4	-	-	-	-	-	-
18	-	12.7	-	-	-	-	10.8	-	-
19	-	14.6	-	-	-	-	-	-	-
20	-	15.0	15.8	-	-	-	-	-	-
21	-	15.0	-	17.4	-	-	-	-	1.1
22	10.5	14.0	15.2	16.2	-	-	-	7.0	-
23	-	-	-	-	-	-	-	-	0.5
24	-	16.2	14.8	-	-	-	-	6.2	-
25	10.8	17.2	-	-	-	-	-	-	-
26	11.0	-	-	-	17.9	-	-	-	-
27	10.0	16.3	-	-	-	-	-	-	-
28	11.0	-	15.9	-	-	-	-	-	-
29	12.9	-	15.9	16.9	-	-	-	-	-
30	12.7	18.0	14.9	-	-	-	-	-	-
31		18.7		-	-		-		-

Table 34. Mean daily water temperature (°C) for Quinsam River at Hatchery (site 21), 1983.

Date	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1	-	13.0	17.5	-	17.6	16.5	10.4	8.1	2.9
2	-	12.5	16.8	-	17.4	16.9	10.3	8.6	3.0
3	-	-	15.3	-	17.0	17.0	10.9	8.4	3.7
4	-	-	16.0	-	16.5	16.7	10.7	7.7	3.2
5	-	12.8	15.3	-	16.8	15.8	10.1	7.1	2.9
6	-	12.8	15.8	16.9	16.6	15.2	9.6	7.1	2.1
7	-	12.0	-	-	17.7	14.8	9.3	7.2	1.9
8	-	10.5	-	-	18.0	14.6	9.4	7.3	1.6
9	-	10.3	-	-	18.5	13.8	9.4	7.2	2.5
10	-	11.5	15.5	-	18.3	13.6	8.7	7.0	2.6
11	-	12.5	15.8	-	18.2	13.7	8.4	-	2.9
12	-	13.8	15.5	-	17.6	14.8	8.4	-	2.8
13	-	13.5	15.3	15.8	18.2	15.1	8.5	-	3.0
14	-	13.0	15.5	15.8	17.6	14.9	8.9	7.3	2.8
15	-	12.8	15.5	15.3	17.2	14.3	8.1	6.8	2.2
16	-	12.8	15.0	15.8	17.1	13.9	7.8	6.9	2.1
17	-	13.3	15.0	17.3	17.5	12.9	9.6	6.7	-
18	-	13.0	14.3	18.5	16.9	12.5	-	6.8	-
19	11.0	13.8	14.8	18.8	16.3	11.8	9.2	7.1	2.0
20	11.5	14.5	15.3	18.3	16.6	11.4	9.3	6.8	-
21	11.8	15.3	15.3	18.0	16.6	12.0	9.6	6.6	-
22	11.8	15.8	14.5	18.3	16.5	12.9	9.7	6.7	-
23	12.3	16.5	14.3	18.8	16.7	13.7	8.6	6.8	-
24	11.3	17.3	14.5	18.8	16.2	14.2	8.1	6.4	-
25	10.3	17.3	-	18.3	16.3	12.9	8.4	6.0	-
26	11.0	16.8	-	16.8	15.8	11.5	8.8	6.1	-
27	10.5	17.0	-	17.0	15.5	12.7	8.4	6.3	-
28	11.5	17.5	-	16.8	15.6	10.3	7.6	5.6	0.2
29	12.8	19.0	-	17.5	15.2	9.9	7.9	4.7	-0.1
30	13.5	18.8	-	18.0	15.8	9.9	8.3	3.7	-0.1
31		17.8		17.8	16.2		7.9		0.1

Table 35. Mean daily water temperature (°C) for Iron River (site 12), 1983.

Date	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1	-	-	9.1	-	-	14.1	-	-	-
2	-	-	-	-	-	-	-	-	-
3	-	-	-	-	-	-	-	-	-
4	-	5.9	-	-	14.0	-	-	-	-
5	-	-	-	-	-	-	-	-	-
6	-	-	-	-	-	-	-	-	-
7	6.0	-	-	11.4	-	-	-	-	-
8	-	-	-	-	-	-	-	-	-
9	-	-	10.8	-	-	-	-	-	-
10	-	-	-	-	-	-	-	-	-
11	-	-	-	-	16.0	-	-	-	-
12	-	8.9	-	-	-	-	-	-	-
13	-	-	-	-	-	-	-	-	-
14	5.0	-	-	11.1	-	-	-	-	-
15	5.0	-	-	-	-	11.4	-	-	-
16	-	-	10.5	-	-	-	-	-	-
17	-	-	-	-	-	-	-	-	-
18	-	-	-	-	-	-	7.6	-	-
19	-	9.0	-	-	-	-	-	-	-
20	-	-	-	-	-	-	-	-	-
21	-	-	10.6	13.3	-	-	-	-	-
22	-	-	-	-	16.2	-	-	-	-
23	-	-	10.7	-	-	-	-	5.0	-
24	-	-	-	-	-	-	-	-	-
25	-	-	-	-	-	-	-	-	-
26	-	-	-	-	-	-	-	-	-
27	-	9.5	-	-	-	-	-	-	-
28	7.4	-	-	13.0	-	-	-	-	-
29	-	-	11.7	-	-	-	-	-	-
30	-	-	-	-	-	-	-	-	-
31		-		-	-		-		-

Table 36. Mean daily water temperature (°C) for Outlet of Middle Quinsam Lake (site 10), 1983.

Date	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1	-	14.7	20.5	17.4	20.9	18.8	-	-	-
2	-	14.5	19.0	17.8	20.4	18.9	-	-	-
3	-	14.5	19.0	17.8	19.7	19.0	-	-	-
4	-	14.5	19.0	17.5	19.5	18.6	-	-	-
5	-	14.8	18.9	17.6	19.7	18.7	-	-	-
6	-	14.2	18.9	17.1	19.9	-	-	-	-
7	-	13.5	18.8	17.0	20.5	-	-	-	3.2
8	9.0	13.0	18.7	17.9	21.1	-	-	-	3.4
9	9.0	14.0	18.6	18.3	21.0	17.5	-	-	3.3
10	9.0	14.9	18.5	17.4	21.0	16.9	-	-	3.2
11	8.8	14.7	18.6	17.1	21.4	16.6	-	-	3.3
12	9.1	13.5	18.7	17.2	21.8	16.4	-	-	3.1
13	9.5	14.8	18.7	17.7	21.7	16.5	-	-	3.2
14	9.6	14.6	18.6	17.4	21.4	16.8	-	-	3.2
15	10.0	15.0	18.7	17.2	21.3	16.7	-	6.9	3.1
16	10.2	15.3	18.7	17.8	21.1	16.4	-	7.1	3.1
17	10.7	14.5	17.0	18.4	21.1	16.0	10.6	7.1	3.1
18	11.4	13.9	17.6	18.8	20.9	16.0	10.8	7.2	3.3
19	12.5	18.0	17.6	19.3	20.9	15.5	10.8	7.3	3.3
20	12.9	17.2	17.5	19.1	21.1	15.4	10.6	7.1	3.4
21	12.0	17.7	17.5	19.0	21.3	15.67	10.5	6.9	3.5
22	11.8	17.9	17.4	19.2	21.0	15.6	10.5	6.0	3.5
23	11.5	18.5	17.6	20.0	20.8	15.9	-	-	3.6
24	12.5	19.4	17.6	20.7	20.4	16.0	-	6.0	3.7
25	13.0	18.5	17.7	20.3	20.2	15.7	-	-	3.8
26	13.2	18.7	17.6	19.6	20.0	15.4	-	-	3.6
27	12.0	18.5	17.6	18.9	19.9	14.8	-	-	3.4
28	14.0	19.0	17.5	18.9	19.1	-	-	-	3.1
29	15.1	19.5	17.9	18.9	19.0	-	-	-	2.8
30	14.4	20.7	18.0	19.5	19.1	-	-	-	2.7
31		21.2		20.6	19.1		-		2.7

Table 37. Mean daily water temperature (°C) for Outflow of Flume Lake (site 8), 1983.

Date	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1	-	14.9	-	-	-	-	-	-	-
2	-	14.4	-	-	-	16.2	-	-	-
3	-	14.0	17.0	-	17.5	-	-	-	-
4	-	14.0	-	15.6	-	-	-	-	-
5	-	13.3	-	-	-	-	-	-	-
6	-	13.0	-	-	-	-	-	-	-
7	-	11.7	-	-	-	-	-	-	-
8	9.0	13.2	-	15.5	-	-	-	-	-
9	-	12.0	-	-	-	-	-	-	-
10	-	13.9	16.2	-	-	-	-	-	-
11	-	13.8	-	-	-	-	-	-	-
12	-	13.1	-	-	19.8	-	-	-	-
13	-	-	-	-	-	-	-	-	-
14	-	-	-	-	-	-	-	-	-
15	11.0	12.5	17.0	15.4	18.8	-	-	-	-
16	-	14.0	-	-	-	13.4	-	6.7	-
17	-	-	16.0	-	-	-	-	-	-
18	-	-	-	-	-	-	-	-	-
19	-	15.6	-	-	-	-	-	-	-
20	-	17.0	-	-	-	-	-	-	-
21	-	16.7	-	17.9	-	-	-	-	-
22	11.0	15.9	15.7	16.9	-	-	-	-	-
23	-	-	-	-	-	-	-	-	1.3
24	-	18.1	14.8	-	-	-	-	-	-
25	11.5	18.6	-	-	-	-	-	-	-
26	13.0	-	-	-	17.5	-	-	-	-
27	-	17.0	-	-	-	-	-	-	-
28	-	-	17.1	-	-	-	-	-	-
29	14.8	-	16.9	17.1	-	-	-	-	-
30	14.2	19.2	15.9	-	-	-	-	-	-
31		20.1		-	-		-		-

Table 38. Non-filterable residue (NFR) for distilled water controls and for replicate samples taken at Outlet of Middle Quinsam Lake (site 10).

Date	Distilled Water Control (mg/l)	Sample 1 (mg/l)	Sample 2 (mg/l)
Jun 10	+ 0.1	0.5	0.5
Jun 17	+ 0.1	1.0	0.5
Jun 24	+ 0.2	0.3	0.4
Jun 30	- 0.3	0.5	0.4
Jul 08	- 0.2	0.4	0.2
Jul 15	+ 0.3	0.7	1.0
Jul 22	+ 0.2	0.3	0.4
Jul 29	+ 0.2	0.2	0.3
Aug 03	- 0.1	0.3	0.3
Aug 12	0.0	0.6	0.3
Aug 26	+ 0.1	0.8	0.8
Sep 02	0.0	0.9	0.6
Sep 16	0.0	-	-
Nov 16	0.0	-	-
Nov 18	0.0	0.7	0.6
Nov 24	- 0.1	0.3	0.3
Dec 04	-	0.6	0.9
Jan 05	-	1.0	1.7

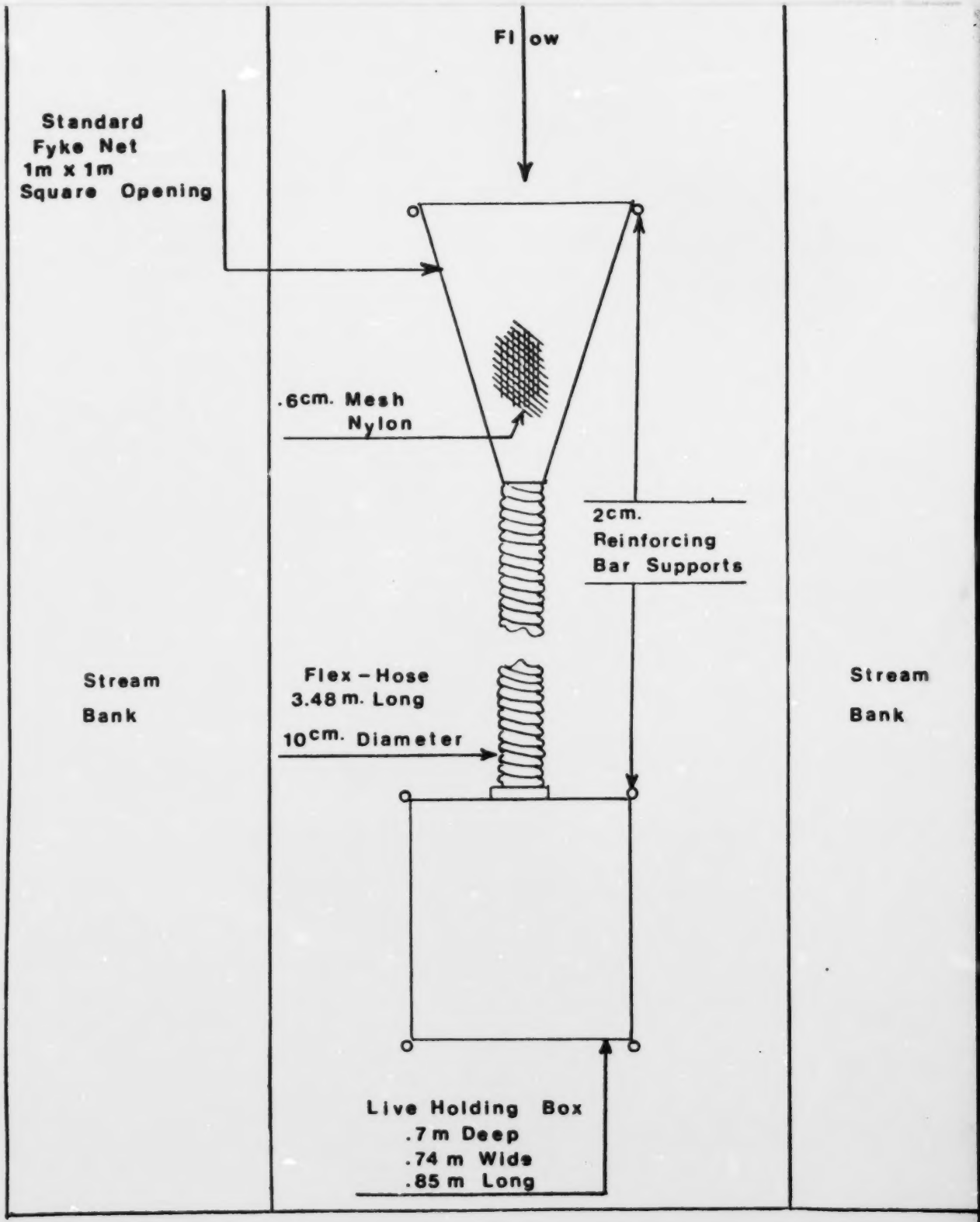

Fig. 3. Trap at Outlet of Long Lake.

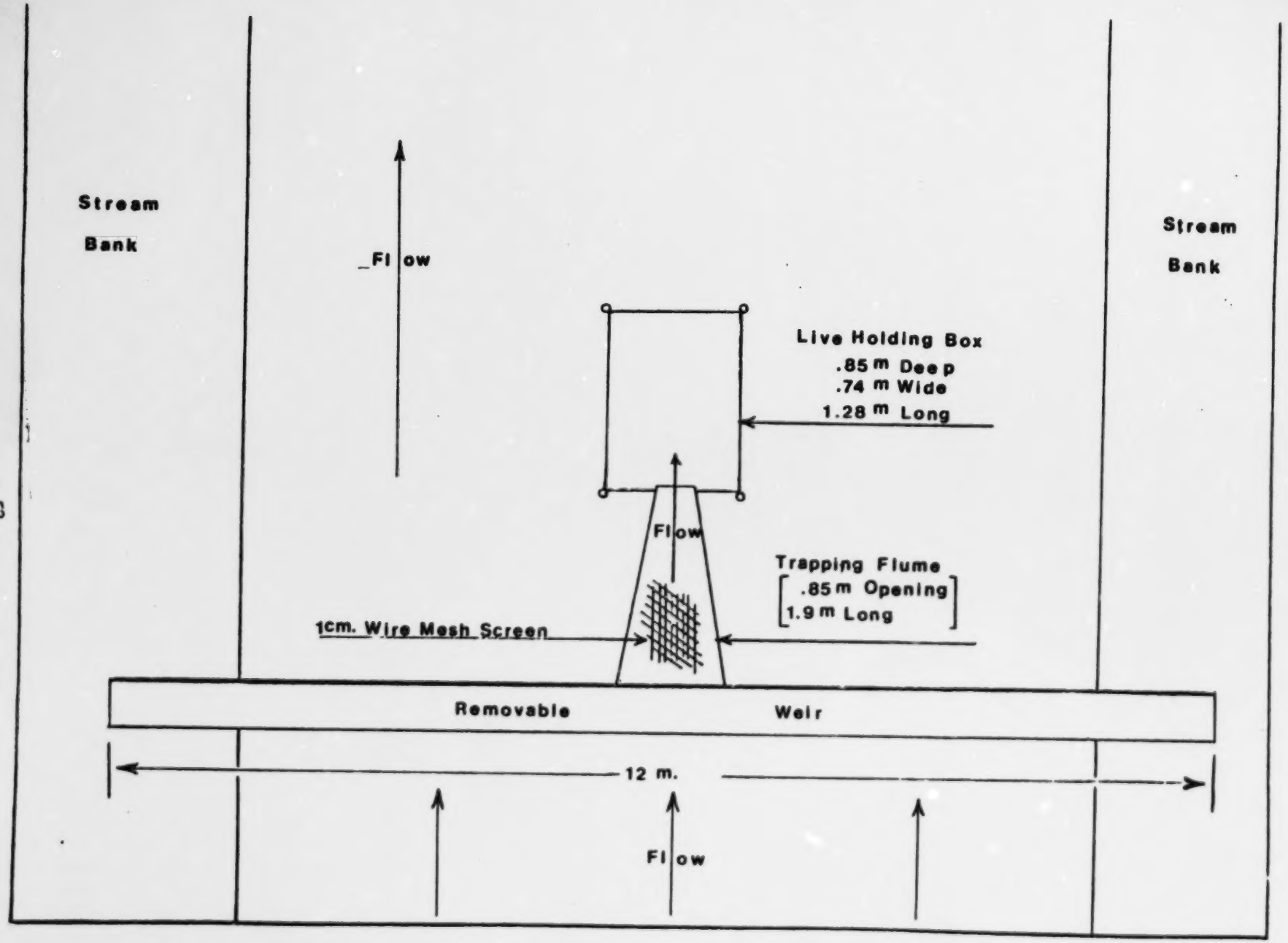

Fig. 4. Trap at Outlet of Middle Quinsam Lake.

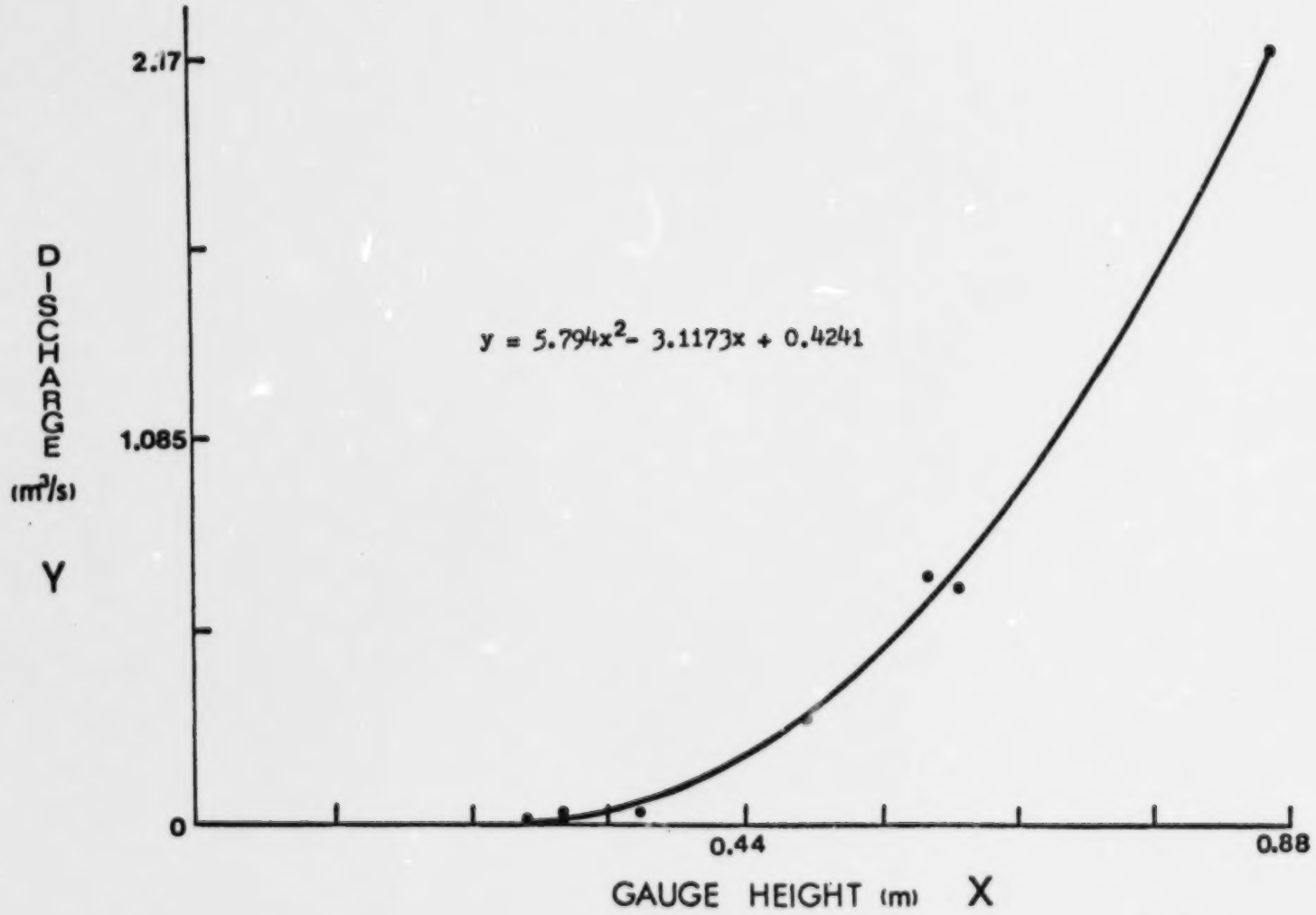

Fig. 5. Relationship between gauge height and discharge for site 3 (Outlet of No-Name Lake). The data used to obtain this relationship are shown in table 4.

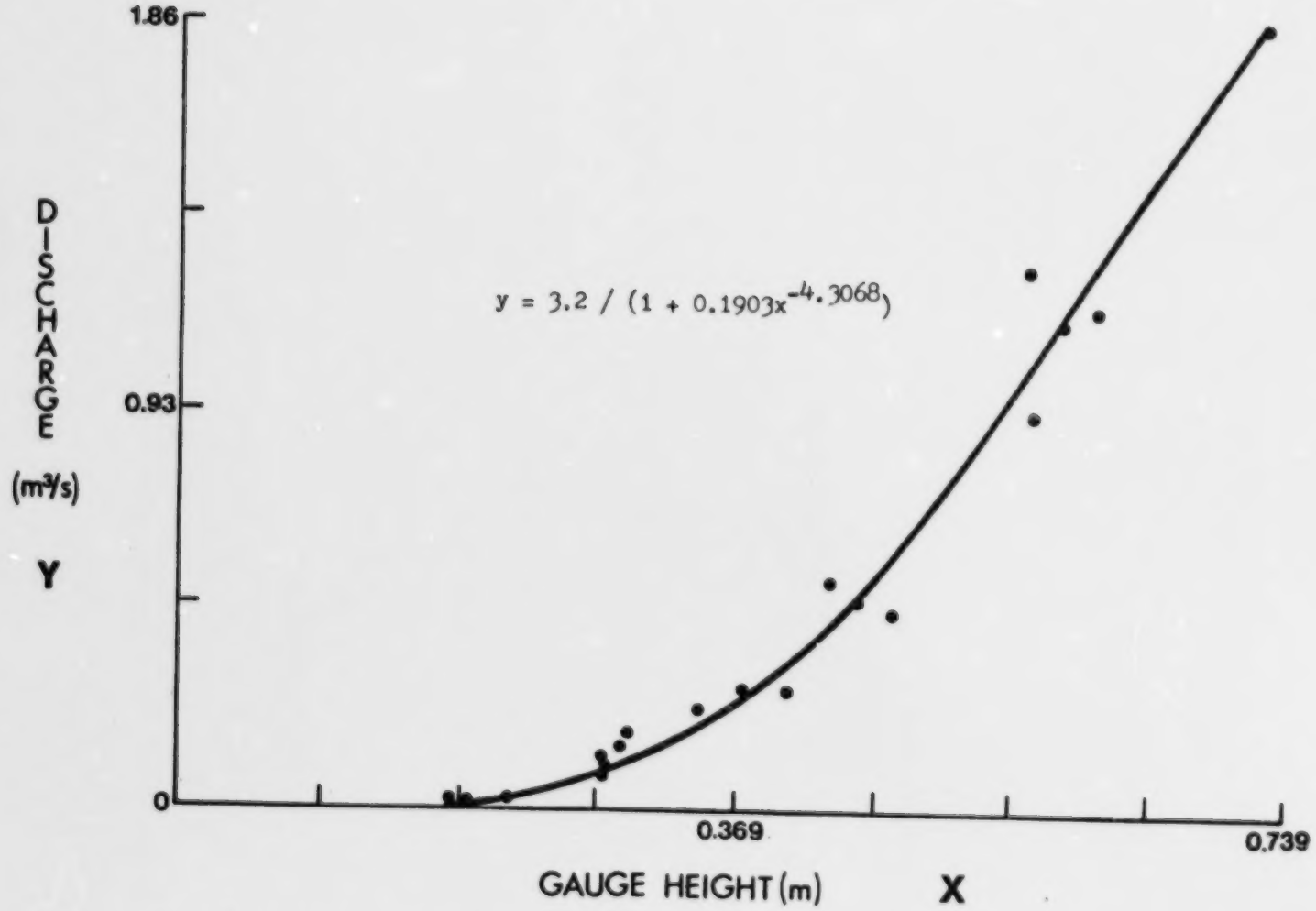

Fig. 6. Relationship between gauge height and discharge for site 5 (Outlet of Long Lake). The data used to obtain this relationship are shown in table 5.

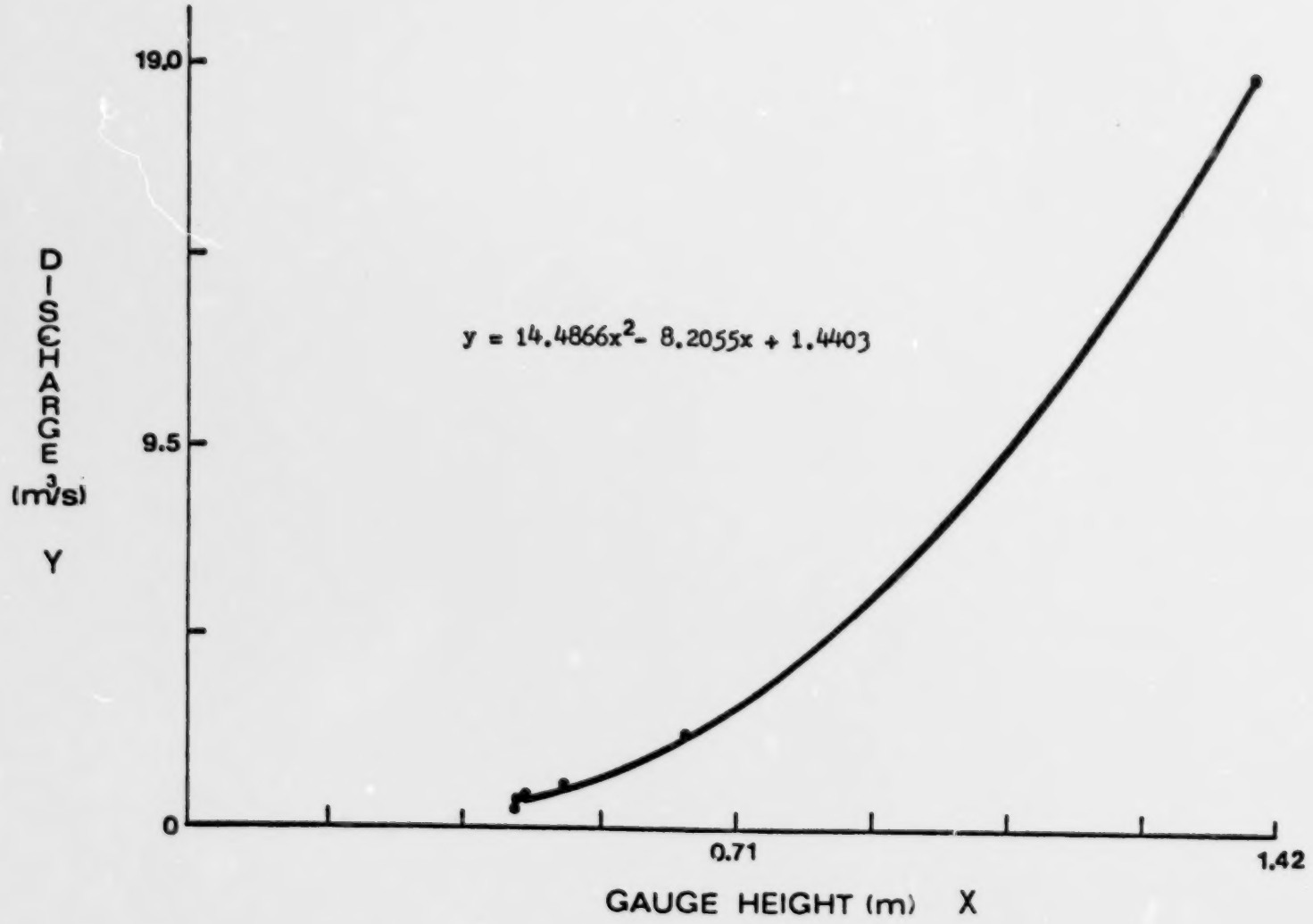

Fig. 7. Relationship between gauge height and discharge for site 10 (Outlet of Middle Quinsam Lake) The data used to obtain this relationship are shown in table 6.

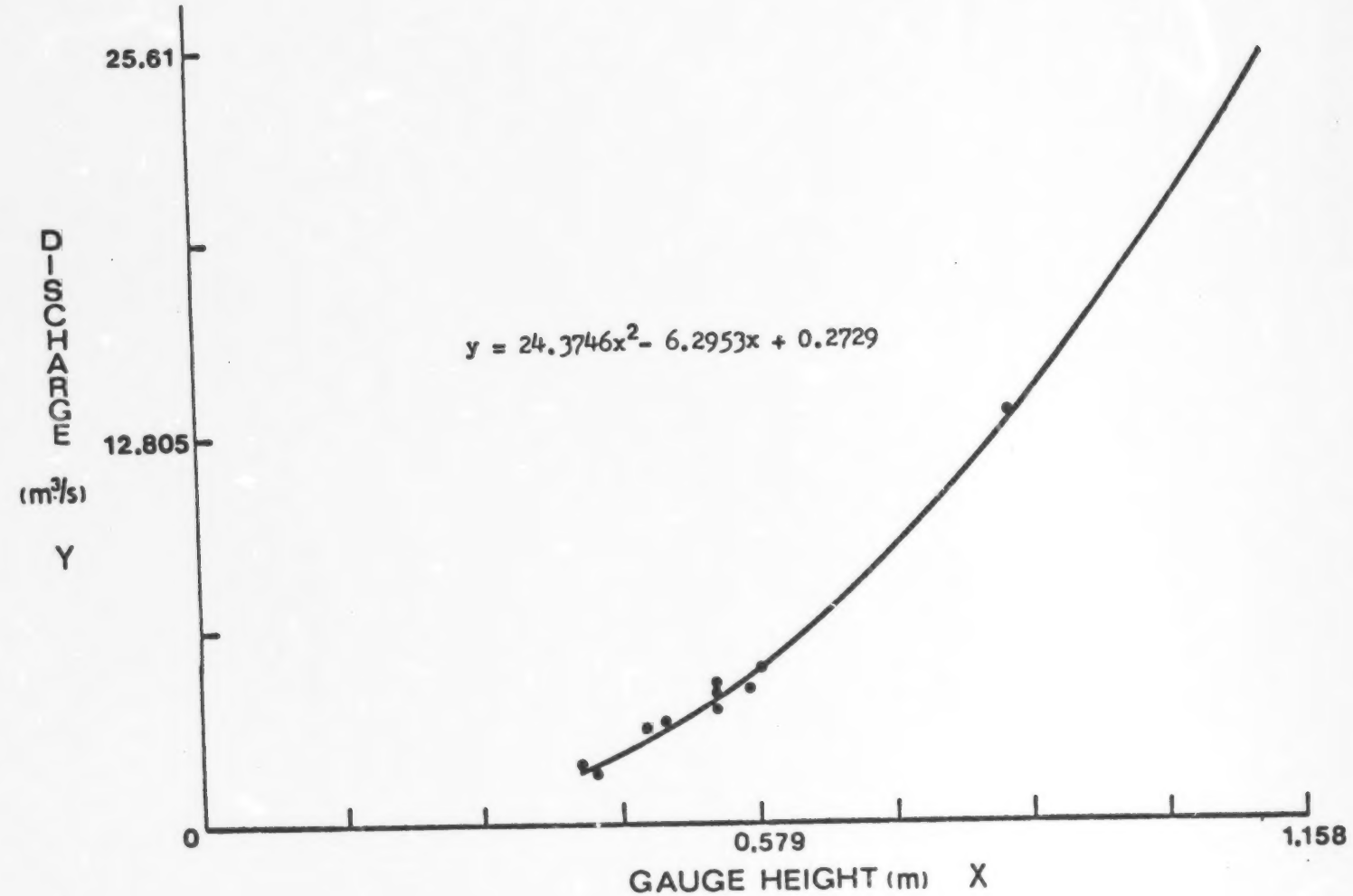

Fig. 8. Relationship between gauge height and discharge for site 21 (Quinsam River at the Hatchery). The data used to obtain this relationship are shown in table 7.

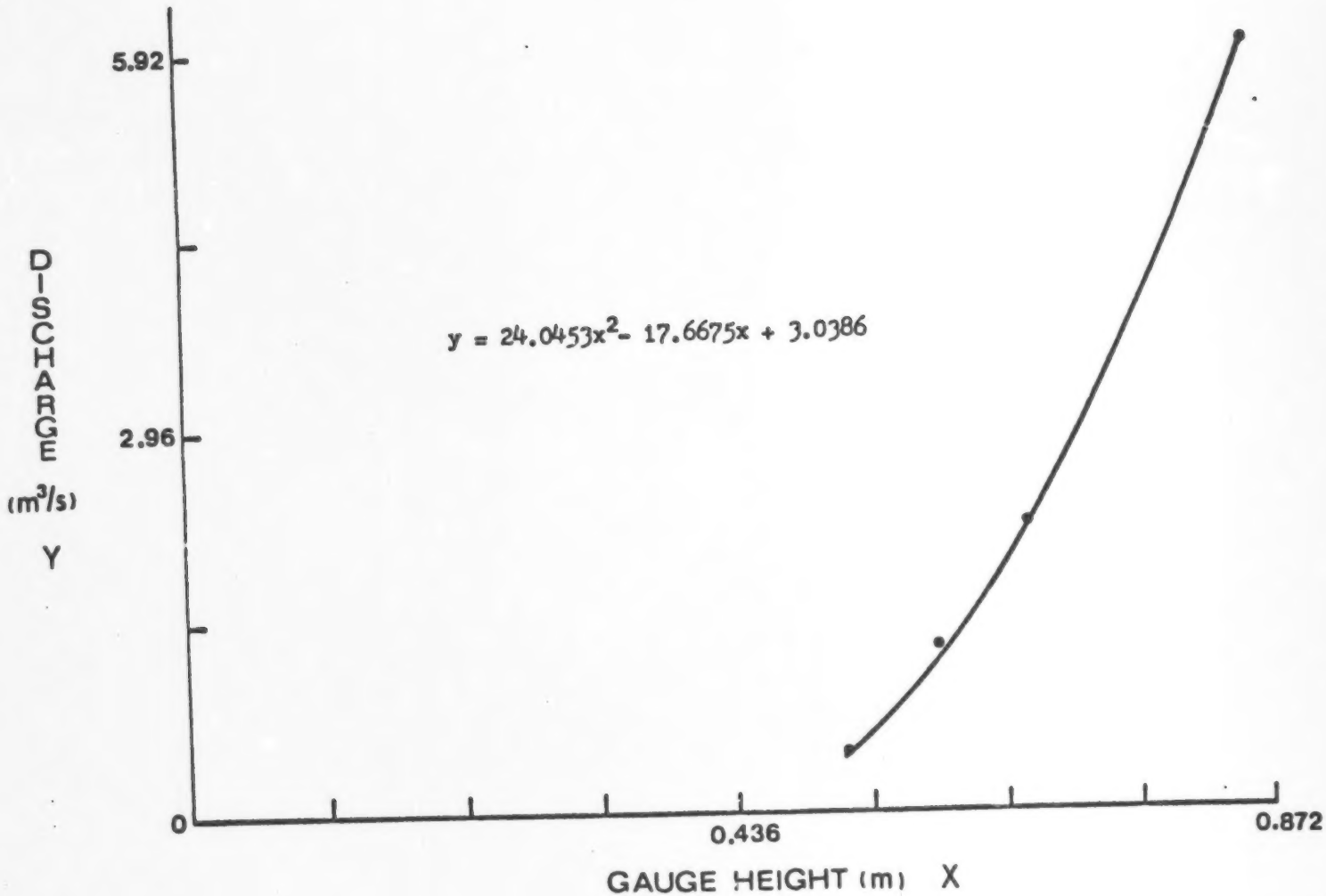

Fig. 9. Relationship between gauge height and discharge for site 12 (Iron River). The data used to obtain this relationship are shown in table 8.

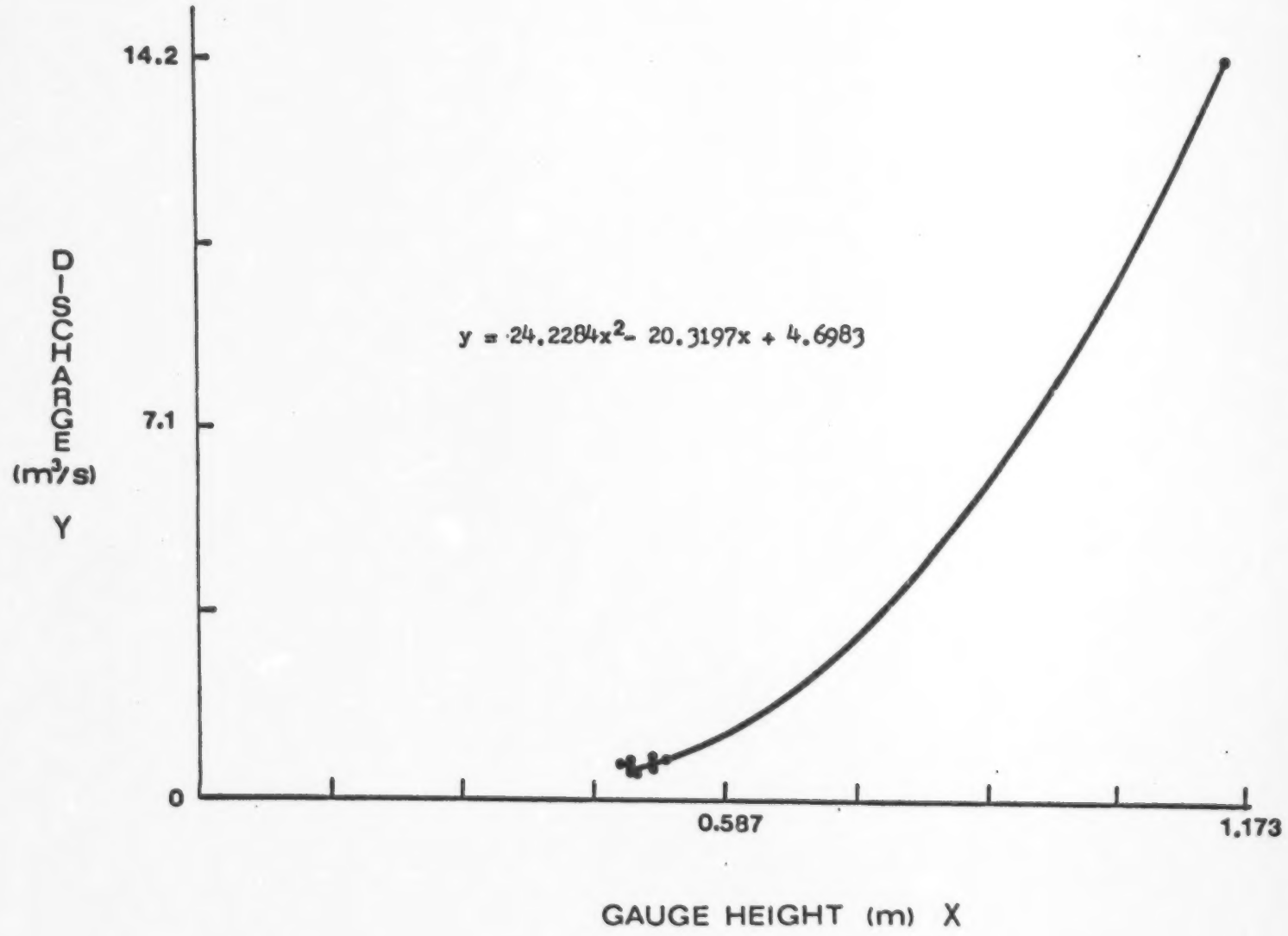

Fig. 10. Relationship between gauge height and discharge for site 7 (Inlet to Middle Quinsam Lake). The data used to obtain this relationship are shown in table 9.

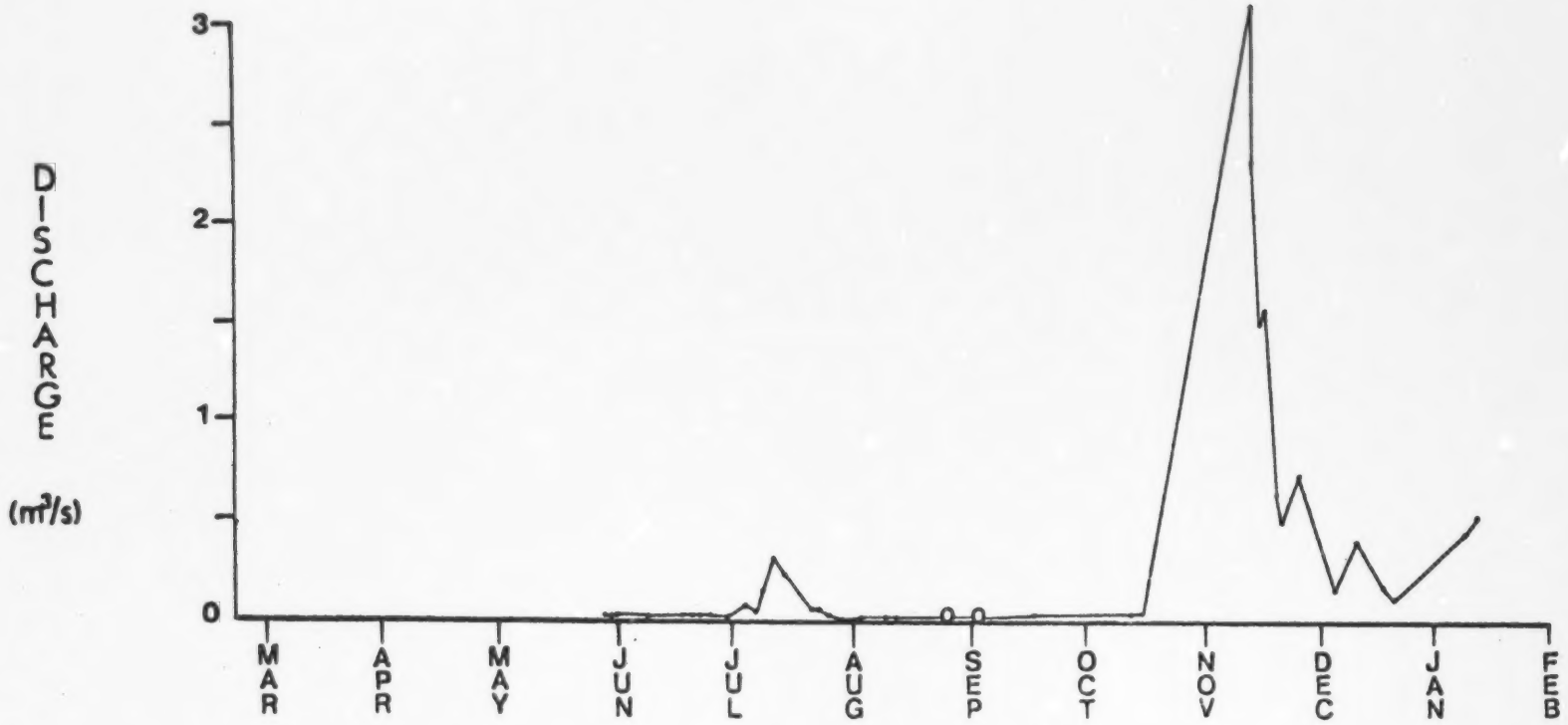

Fig. 11. Discharge versus time, May 1983 - January 1984, for site 3 (Outlet of No-Name Lake). Solid points represent the flows calculated from the discharge curve for this site (refer to fig. 5). Open points represent flows less than 0.0048 cms (cfs = 35.3 x cms).

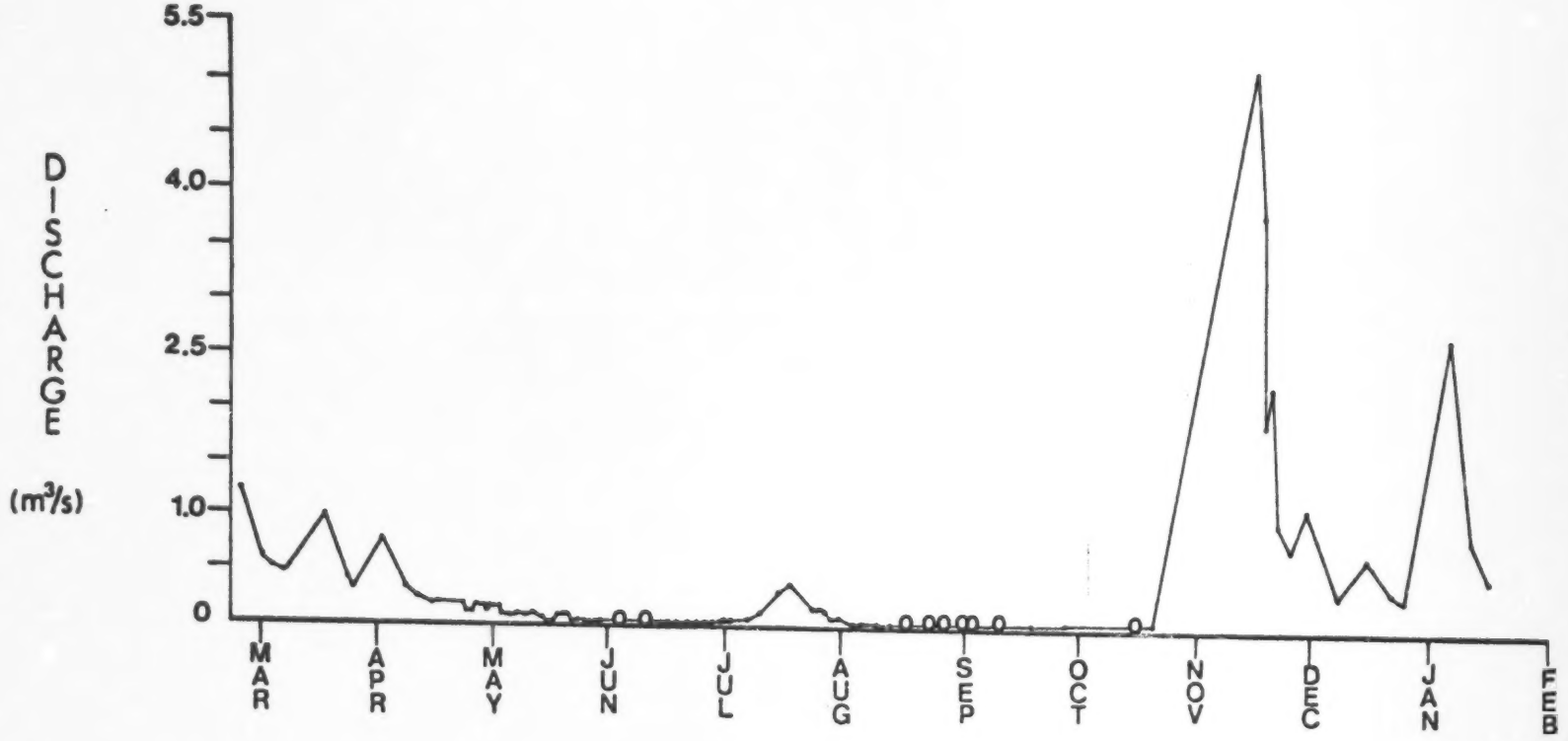

Fig. 12. Discharge versus time, March 1983 - January 1984, for site 5 (Outlet of Long Lake). Solid points represent the flows calculated from the discharge curve for this site (refer to fig. 6). Open points represent flows less than 0.01 cms (cfs = 35.3 x cms).

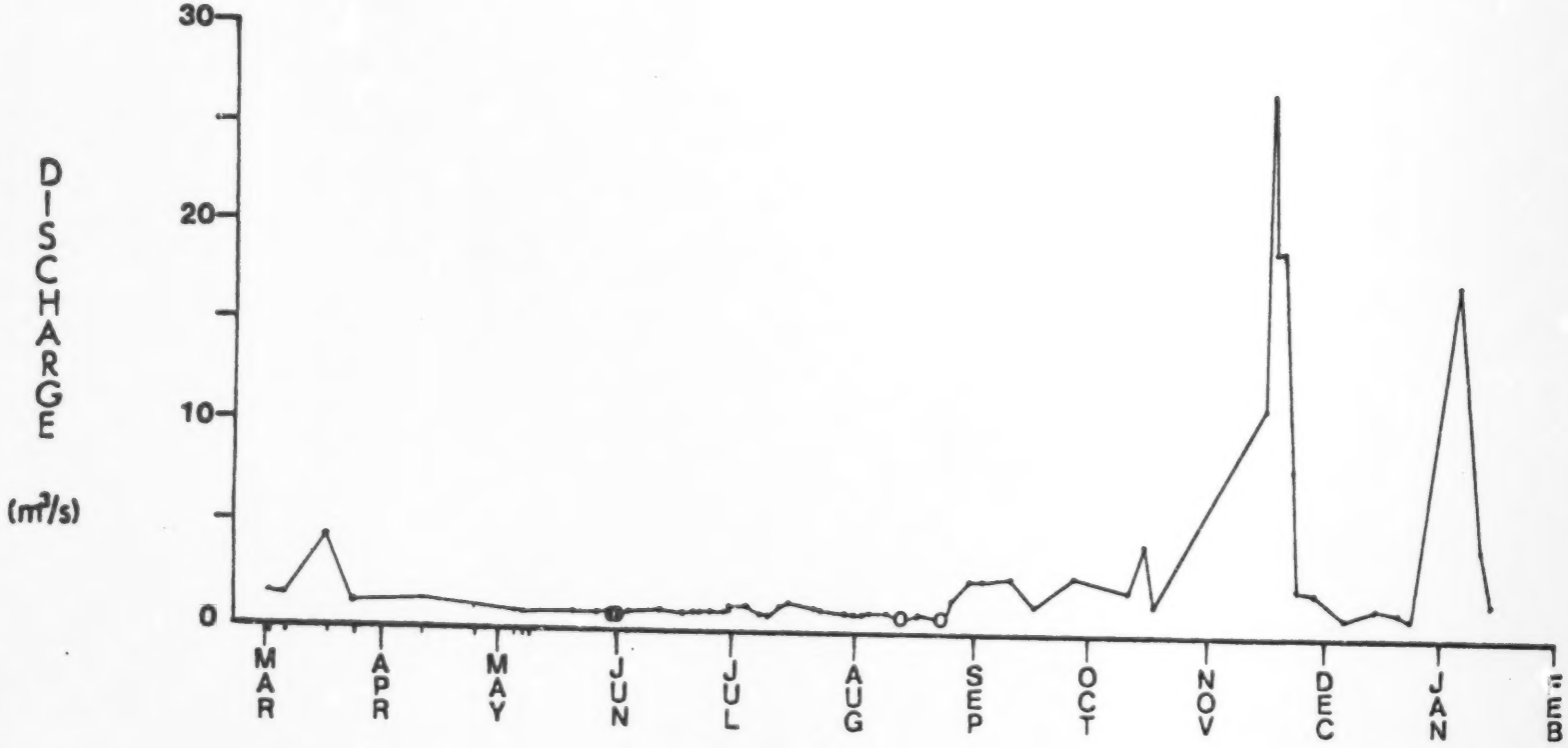

Fig. 13. Discharge versus time, May 1983 - January 1984, for site 10 (Outlet of Middle Quinsam Lake). Solid points represent the flows calculated from the discharge curve for this site (refer to fig. 7). Open points represent flows less than 0.63 cms (cfs = 35.3 x cms).

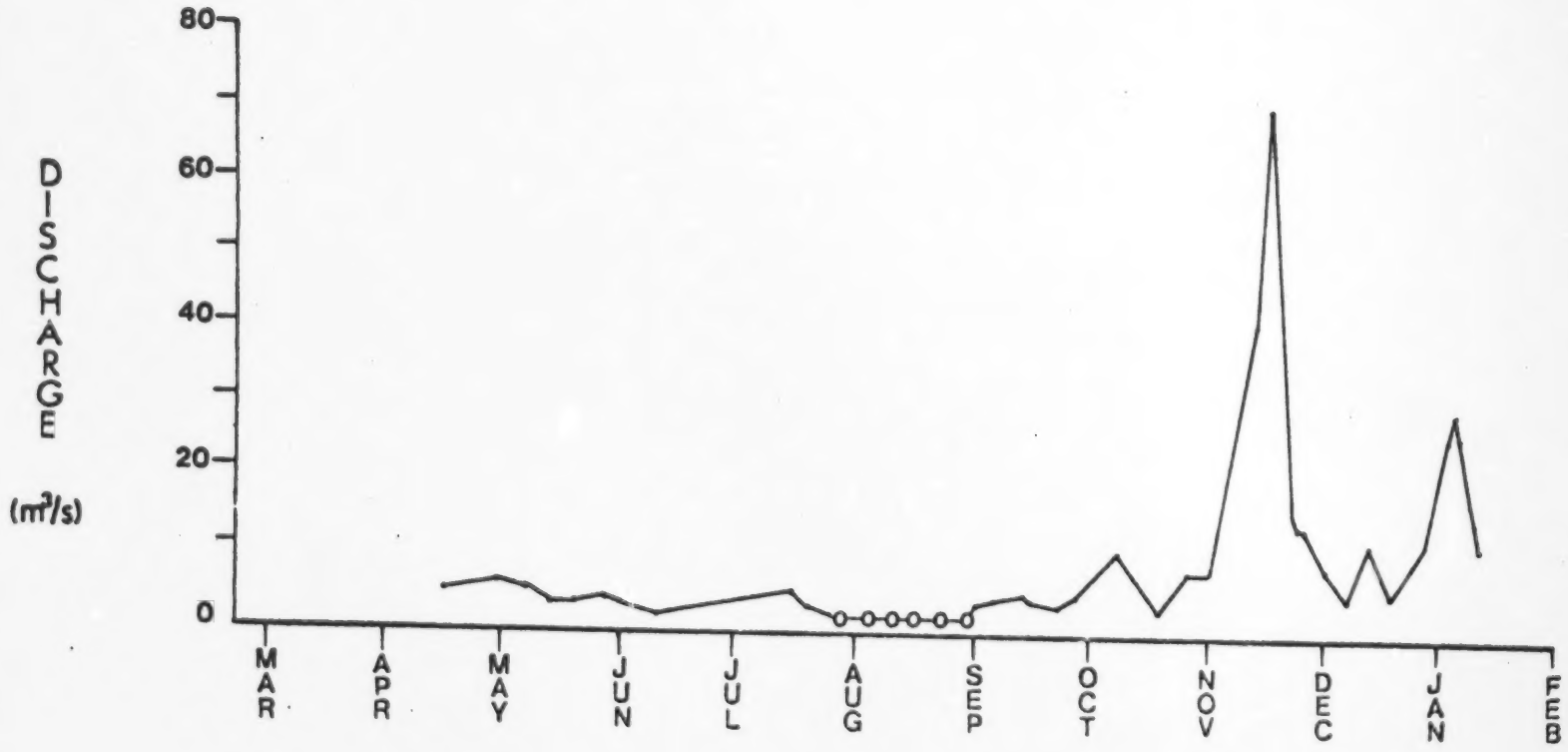

Fig. 14. Discharge versus time, April 1983 - January 1984, for site 21 (Quinsam River at the Hatchery). Solid points represent the flows calculated from the discharge curve for this site (refer to fig. 8). Open points represent flows less than 1.65 cms (cfs = 35.3 x cms).

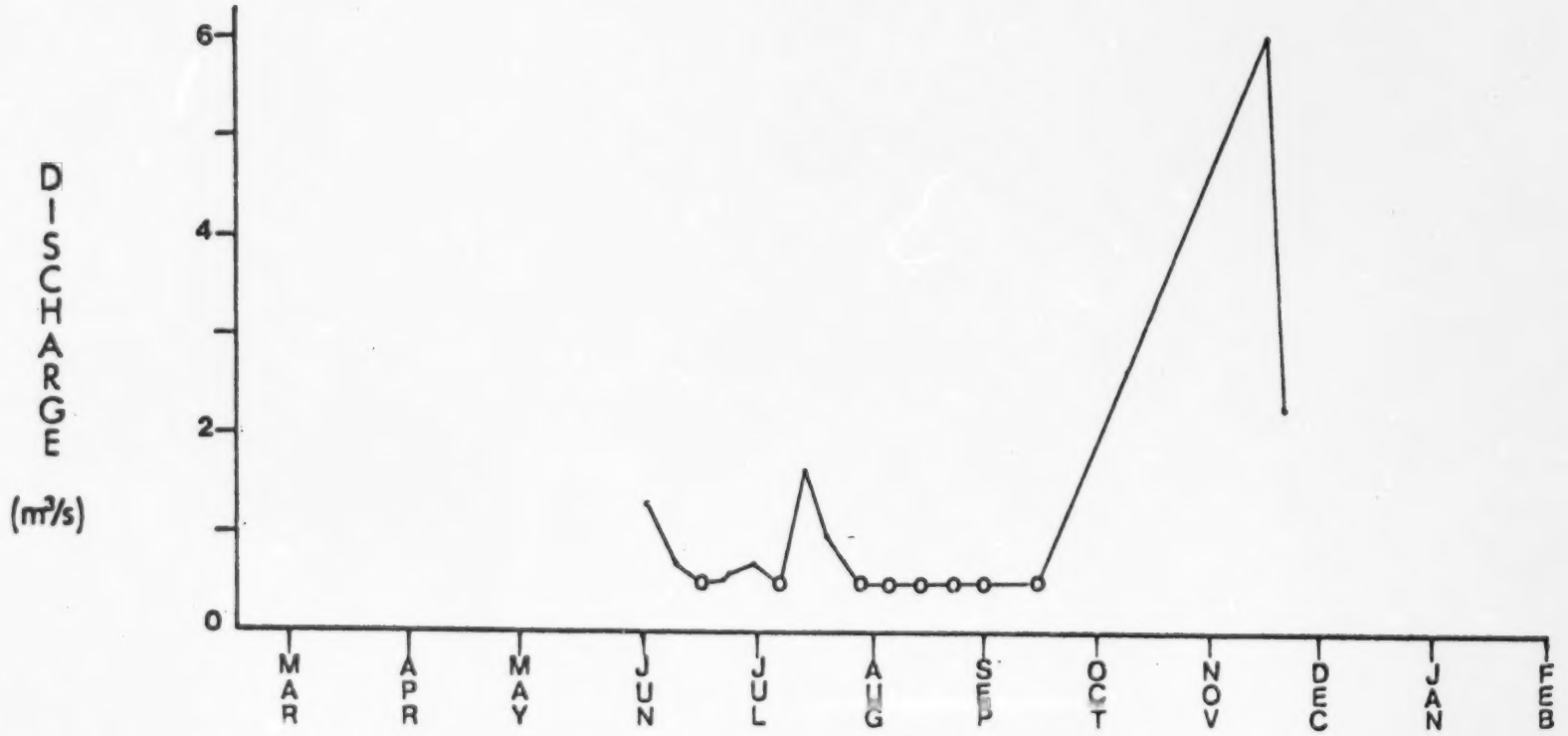

Fig. 15. Discharge versus time, June 1983 - November 1983, for site 12 (Iron River).
Solid points represent the flows calculated from the discharge curve for this site (refer to fig. 9).
Open points represent flows less than 0.46 cms (cfs = 35.3 x cms).

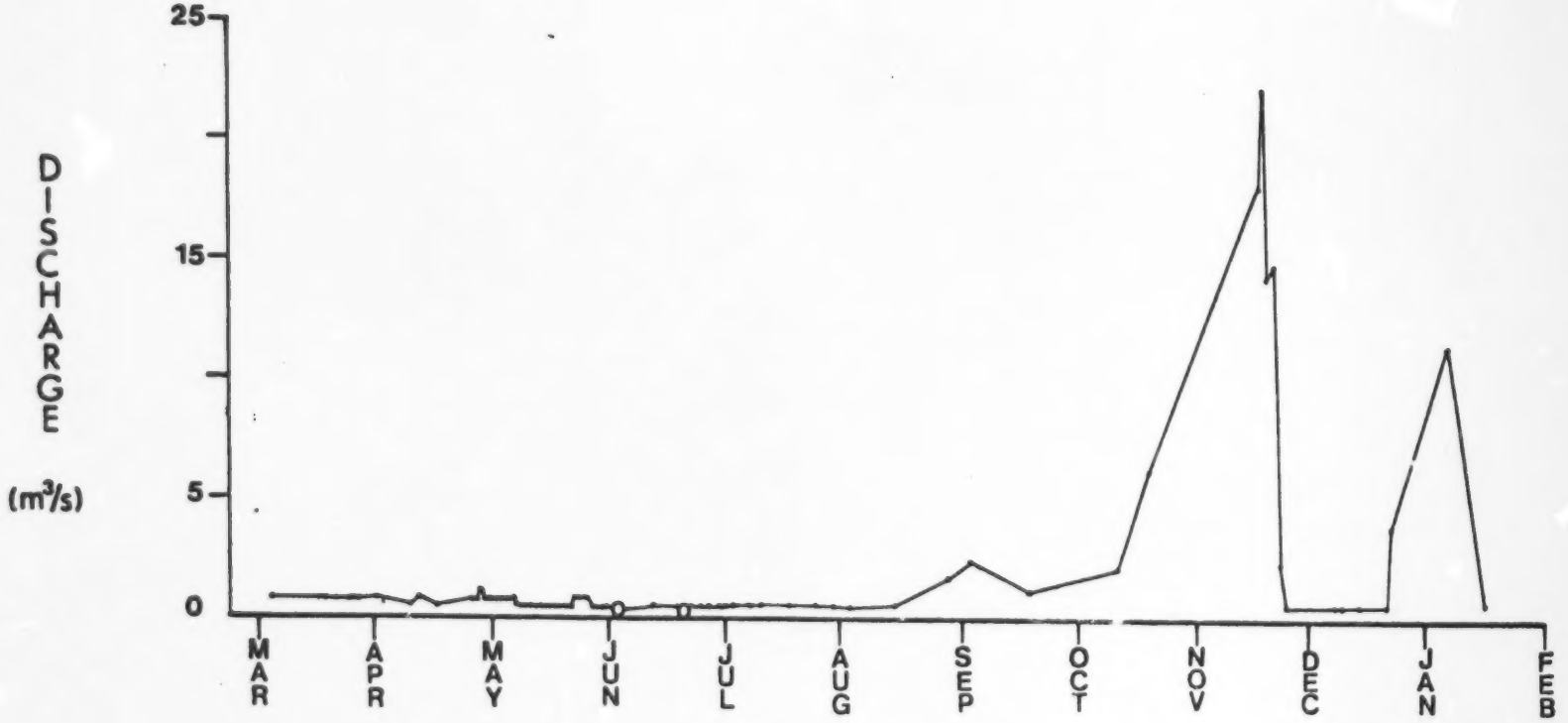

Fig. 16. Discharge versus time, March 1983 - January 1984, for site 7 (Inlet to Middle Quinsam Lake). Solid points represent the flows calculated from the discharge curve for this site (refer to fig. 10). Open points represent flows less than 0.52 cms (cfs = 35.3 x cms).

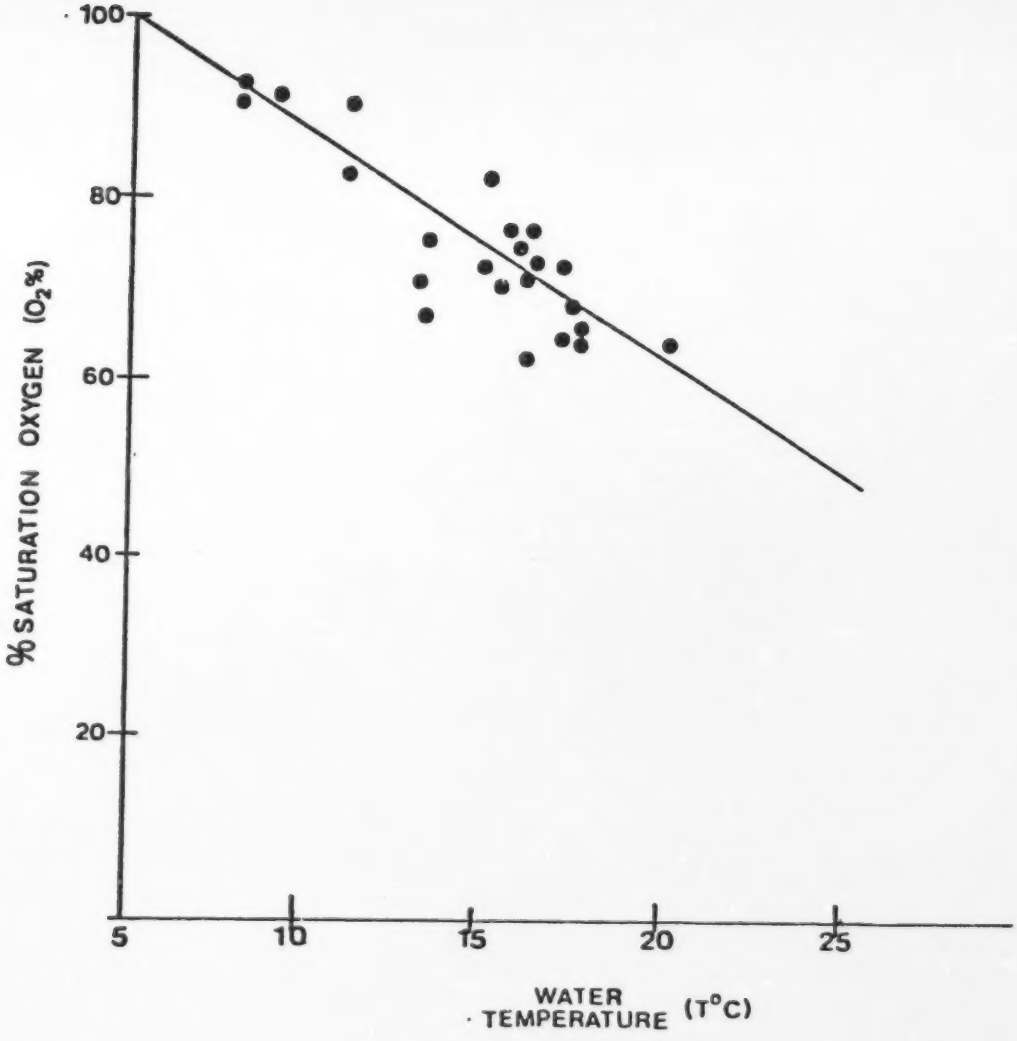

Fig. 18. Percent oxygen saturation vs water temperature at the Outlet of Flume Lake (site 8).